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What is the Most Effective Water Policy for the United States?

National Debate Topic for High Schools
1985-1986

Pursuant to Public Law 88–246

Compiled by the Congressional Research Service
Library of Congress

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PUBLIC LAW 88-246, 88TH CONGRESS, S. 2311,

DECEMBER 30, 1963

AN ACT To provide for the preparation and printing of compilations of materials relating to annual national high school and college debate topics.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Librarian of Congress is authorized and directed to prepare compilations of pertinent excerpts, bibliographical references, and other appropriate materials relating to (1) the subject selected annually by the National University Extension Association as the national high school debate topic and (2) the subject selected annually by the American Speech Association as the national college debate topic. In preparing such compilations the Librarian shall include materials which in his judgment are representative of, and give equal emphasis to, the opposing points of view on the respective topics.

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Approved December 30, 1963.

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Congressional Research Service
The Library of Congress

Washington, D.C. 20540

FOREWORD

The 1985-1986 high school debate topic is, "What is the most effective water policy for the United States?" The three official debate propositions within this topic are:

> RESOLVED: That the Federal Government should implement a national system of priorities to control the allocation of all water in the United States.
>
> RESOLVED: That the Federal Government should establish a comprehensive national policy to protect the quality of water in the United States.
>
> RESOLVED: The the Federal Government should establish a national policy to insure each United States resident an adequate supply of potable water for personal use.

In compliance with Public Law 88-246, the Congressional Research Service of the Library of Congress prepared this compilation of materials and bibliographic references to assist high school debaters in researching this year's topic. The excerpts from books, periodicals, and other documents were selected to provide background information, an overview of the principal issues, and a balance of opposing views. We also included some materials that are not readily available in public or research libraries. Bibliographic references were also chosen to provide a wide range of information and opinions. In selecting items for this reader and bibliography, the Congressional Research Service (CRS) has attempted to sample the wide spectrum of opinions reflected in current literature on these questions. No preference for any policy is indicated by the selection or positioning of articles herein, nor should one infer CRS disapproval of any policy or article not included.

The selected items have been arranged in four sections. The first section presents background materials which can help debaters educate themselves on key aspects of water policy issues. Items in the other three sections were chosen for their relevance to the three official debate resolutions.

U.S. Government documents listed in the bibliography may be found in most U.S. Government depository libraries which can be identified by your local public library. The Library of Congress cannot distribute copies of these or other materials to the debaters.

Information is included at the end of this volume on guides to additional resources and other publications and associations that may be useful in expanding and updating this compilation. Finally, there is included a list of relevant publications that are available for purchase from the Superintendent of Documents, Government Printing Office.

The documents included in this compilation were selected by Rebecca Mazur, Bibliographer in Environment and Natural Resources, Library Services Division; Donald V. Feliciano, H. Steve Hughes, and Malcolm M. Simmons, Analysts, Environment and Natural Resources Policy Division; and Duncan Hollomon, Legislative Research Assistant, American Law Division. The bibliography was compiled by Ms. Mazur and Mr. Feliciano, with assistance from Mr. Hughes and suggestions from Mr. Simmons and Mr. Hollomon. Ms. Mazur prepared the guide to information sources in water policy. Sherry Shapiro, Senior Bibliographer, Library Services Division, coordinated the preparation of this debate manual for publication. Barbara Sanders secured copyright permissions. Lisa Barker, C. Lee Burwasser, Barbara Hall, and John M. White assembled and prepared items for publication. Ann Eschete provided the secretarial production of the bibliography and research guide.

The Congressional Research Service wishes to express its appreciation to those copyright holders that have granted permission for the reproduction of materials. Such permission is acknowledged in each instance.

Good luck to each debater in researching, preparing, and presenting arguments on this year's topic.

Gilbert Gude
Gilbert Gude
Director, Congressional Research Service

I. GENERAL MATERIALS

Reprinted with permission of The Conservation Foundation, a Washington, D.C.-based nonprofit environmental research group. This material is excerpted from the Foundation's STATE OF THE ENVIRONMENT: AN ASSESSMENT AT MID-DECADE, a comprehensive report on environmental conditions and trends. (1984).

Chapter 7

Water Resources

Apocalyptic headlines in magazines and newspapers, proclaiming water shortage and contamination, raise the specter of water quantity and quality as the "energy crisis of the 1980s." At the same time, the lives and habits of most Americans remain largely or entirely untouched by water perils or prognostications. Does this prove the doomsayers wrong, or suggest instead that the U.S. "water outlook now is frighteningly reminiscent of the oil outlook a decade ago—affording, cynics say, a matchless opportunity to make the same mistakes again"?[1]

Many experts agree that most water problems do not result primarily from physical limitations or technical inadequacies.[2] Water shortages, while growing in number and seriousness, are still fairly unusual. And, certainly, technical means are available for dealing with most contamination problems—at least of surface water. But, as in the case of energy, water problems could be compounded as a result of imprudent and misguided human choices. Such choices typically are shaped by market imperfections and by unwise government policies, including narrow-purpose programs, long-established subsidies, and inappropriate legal constraints. Because many of today's water crises stem largely from government policies and human desires and habits rather than physical or technological limitations, crises over water often are susceptible to, and prevented by, changes in the ways legal, political, economic, and social institutions deal with water. The real question is whether the institutional adjustments necessary to respond to conditions of increased scarcity can be made before it is too late.

Such changes, necessary as they may be, generate bitter conflict. Farmers, urbanites, industrialists, professional and sport fishers, environmentalists, and officials of different states all find themselves competing for water, the purity and availability of which suddenly carry a high price. Water administrators and legislators accustomed to distributing largess to appreciative constituencies now find that the limited availability of both water and money forces decisions that outrage

The Conservation Foundation is a nonprofit research and communications organization dedicated to encouraging human conduct to sustain and enrich life on earth. Since its founding in 1948, it has attempted to provide intellectual leadership in the cause of wise management of the earth's resources.

various parties. In short, water allocation and treatment programs developed under conditions of surplus and subsidy must adapt to conditions of mounting shortages and heated competition.

Water problems, obviously, are most likely to be noticed when they become tangible—be they manifested as groundwater pollution in New Jersey, flooding along the Colorado River, groundwater depletion in Illinois, or the drying up of the Everglades Swamp in Florida.[3] These situations may worsen, and others, less pressing now, are likely to erupt. But underlying all these specific problems are some generic issues relating to water use and management in the United States. Three of the most fundamental issues are: For what purposes are supplies of water to be used? Who should decide how to allocate water? Who should pay for water investments?

These questions, and the range of answers to them, are the focus of this chapter. Future decisions about water supply, allocation, and financing will less and less resemble those of the past because of environmental, political, and financial flux. Among the factors forcing change are the swelling demands for limited water supplies, the unabated desire for improved water quality, the emergence of stronger interests competing for water, recent court decisions limiting the authority of states to manage water, and scarcity of federal money for water development. These trends cloud the forecast for water resources. But clearly many of the stresses are caused by, and thus any resolutions will have to respond to underlying value conflicts.

VALUES IN CONFLICT

Probably no other natural resource carries such varied and conflicting personal and social values as water. ‘We made from water every living thing,” says the Koran.[4] Water is essential to human life, and this essence can be the source of economic wealth, the creator of beautiful environments, and a telling element of many cultures. A study of six irrigation communities in Spain and the western United States concludes that water usage in them relates to “the justice of institutions—to the relations in irrigation communities among popular control, distributive shares, economic growth, and farmers' concepts of fairness.”[5] Plato and Aristotle probably were not the first to recognize that the values to which water is applied have far-reaching implications for the nature of human society.[6]

The Basic Values

The clash of conflicting values is at the heart of most of the battles over water fought in this country and abroad. In the United States, four distinct values have been recognized as legitimate purposes of water-resource development*: economic efficiency, equity, environmental quality, and regional economic development.

The last of these, economic enhancement of an area, even though it was the great motivating force behind the creation of the U.S. Bureau of Reclamation and the Tennessee Valley Authority, has, since the mid-1970s, been discredited as a continuing justifiable purpose for federal investments by successive presidential administrations and some members of Congress.[8] They have realized that benefits generated for one region may not be newly created but rather may merely be shifted from another region (as when the irrigation of western cotton displaces southern cotton). Now, regional development is no longer considered a consensus goal of water investment.

Definitions of the remaining three values—economic efficiency, equity, and environmental quality—vary widely among users and contexts. Each has strong defenders, though those defenders may, at least implicitly, mean different things when using the terms. Economists, for example, traditionally define as efficient those projects with net national benefits that exceed net national costs, regardless of who receives the benefits or pays the cost. Such calculations, however, are easily manipulated, and the result may well depend more on the dullness, imagination, or zeal of the estimator than on any intrinsic worth associated with a proposed project.

Some people use the terms *economic efficiency* and *free-market decisions* interchangeably. They may do so for ideological reasons, because process is confused with result, or because the association happens to serve particular interests. In any case, during a time of water scarcities and tight budgets, the efficiency argument is relied on heavily by project proponents and opponents alike. In fact, substantial economic inefficiencies in the existing system appear to be causing many current

---

* These values, and the conflicts among them, were formally recognized in a federal water-planning document called "Principles and Standards for Planning Water and Related Land Resources," which was developed, after substantial conflict, to guide federal decisions on proposed water-resource developments.[7] The "principles" established four separate analytical categories, or "accounts": national economic development, environmental quality, social well-being, and regional development.

"shortages" and conflicts.[9] In many regions, the view seems to be that water is so valuable that it should be virtually free; as a result, most water users pay far less than the actual cost of water service. The ultimate result is pervasive waste—leaking water-supply mains left unrepaired, excessive amounts of water spread on low-value crops, and lawn sprinklers left running all night. Society may no longer be able to afford the obvious inconsistency between such waste and the high economic, environmental, and cultural importance claimed for water.

The term *equity* takes on an even greater range of meanings. People who have water offer the equity argument to oppose any action that might result in their receiving less, or paying more for what water they do receive. It is not equitable, the "haves" argue, to change the rules of the game. For example, several western states such as Montana restrict the transfer of water rights, especially out of irrigation to industry, emphasizing the protection of existing cultures or lifesyles.[10] This form of the equity argument may be resorted to even before the game has started. Thus, Congress's past approval (or "authorization") of a project continues to be taken as a promise that the project will be built, even though the conditions may have changed substantially during the decades since the approval occurred (or, in extreme cases, though it may be realized that there is no water to fill the project)[11] or even though many who originally voted in favor of the authorization never really expected the project to be constructed.

But this expedient concept of equity is used only by those who already have, or would obtain, the project's water. The waterless use *equity* to quite a different end, arguing that the term means providing water to those who have none, even if it must be taken from someone else.

Recognizing many inequities is a Solomonic task. For example, is it unfair if downstream residents must pay to treat water because of wastes discharged by their upstream neighbors, even though requiring a city to treat its own wastes does not necessarily increase (and may decrease) net economic efficiency?[12] Should water be saved for all the states in a basin even though only some of those states can use it efficiently at present? Without "equitable apportionment," ad hoc water use may reach a point at which states deprived of water and the resulting economic development feel they are being told, "We've got ours; you're out of luck."[13] Should free-flowing rivers, as wilderness, be preserved so that choices about their disposition can be left to future generations?

Environmental quality also has many guises. For example, it is cited both to defend and oppose the same project because, on one hand, environmental quality will create a favorable reservoir environment for certain types of fish and recreation and, on the other hand, it will drown out a valued natural fishing and boating stream. Similarly, a project may simultaneously create and destroy wetlands.

Many environmental-quality values are easy to recognize in the abstract. For example, clean water is better than dirty water, and more wildlife is better than less. But the value may become much less distinct in specific situations: Are more trout better than more squawfish? Is it desirable to have cleaner water even though there is less of it left in the river?

Of course, project supporters and opponents are likely to use—and misuse—any argument they can. But there is little question that the values of efficiency, equity, and environmental quality, as commonly understood, will be affected, and often diminished, by any proposal to deal with water quality or quantity. Almost all water-resource decisions involve consideration of all three of these values; some involve substantial trade-offs and, therefore, conflicts between them. Harmonization of these values becomes paramount for most projects or programs, because it is politically difficult to take any action perceived as slighting any one of them.

Institutional change, it should be noted, already is under way throughout the United States. Intensive scrutiny of new water projects is now an accepted part of the procedure for winning congressional authorization. Respected observers declare that the day of mammoth new waterworks is over; the time for cost-effective management is at hand.[14] Water-banking schemes, to improve the transferability and thus the market pricing of water, are springing up in a number of states.[15] Charges based on actual use of water are used more often by municipalities for water supply and wastewater treatment. Reorganization of state water agencies along functional lines is more common.

Examples of Conflicts

The sharpest conflict is often over perceptions of efficiency and equity—when the use of water to provide the greatest economic productivity clashes with the expectations of a small or poor group.

The flooding along the lower Colorado River in the summer of 1983 is a classic example. The many reservoirs with huge capacity along the Colorado were built for both water supply (requiring that the dams store water) and flood control (which requires that the dams not store too much water).[16] In response to strong state preferences for the many valuable, water-dependent uses that had sprung up in the river basin, the U.S. Bureau of Reclamation filled Hoover Dam well into the portion of storage capacity historically allocated (under the unamended priorities of the law authorizing the dam) to flood control.

When unusually massive late-spring runoff roared down the Colorado in June 1983, the bureau could only let it surge around the full dams and cause over $50 million of damages to downriver Arizona and California towns, which had been built, at least in part, with the expectation that the dams would protect them from such floods. In defense of the bureau, some cite the western saying that "a flood costs millions; a drought costs billions." However, although the damage likely to result from inadequate Colorado River storage during drought probably would be far greater—justifying on efficiency grounds the tacit decision to overfill the reservoirs—few could argue with the flood victims' claims of unfair treatment.[17]

The problem of how best to use existing reservoir capacity is not only a western one. Growing urban areas in the East and South also seek to fill "empty" flood-control dams for supply purposes. The Washington, D.C., area has congressional approval to reallocate flood storage to urban supply in western Maryland's Bloomington Dam on the Potomac River (figure 7.1). Similar plans are in the works for the Kowanesque Reservoir in Pennsylvania, and more can be expected.[18]

Supply conflicts—and their redress—work both ways, as with the massive allocation (and potential reallocation from existing users) of western water to meet the long-standing claims of American Indian tribes. Because much of the Indians' water will be funneled to marginal agriculture (although some probably will be leased to uses with higher economic values), this allocation is both inefficient and ironic, coming at a time when scarcity is driving western water prices higher and is driving water itself toward urban and industrial applications. It is, however, a redress amply justified by the centuries-old abrogation of Indian resources by non-Indians, and it also upholds equity by recognizing the cultural value of water to the western tribes.

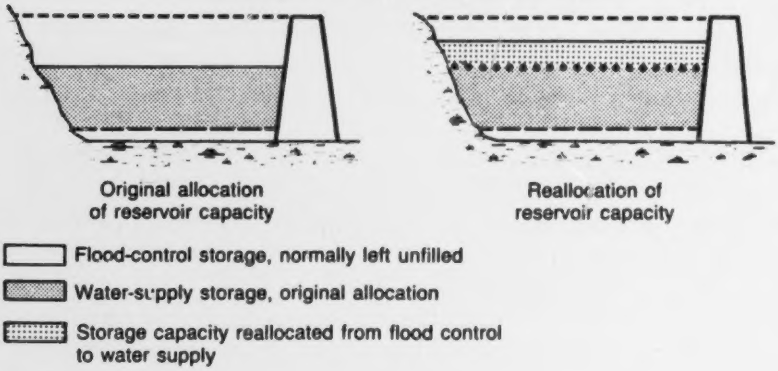
Another example is provided by Charles County, Maryland, where poor, rural residents depend on groundwater from shallow wells. New subdivisions in the county—a growing Washington, D.C., "bedroom" community—can afford to dig deeper wells, drawing the water away from the original residents or spreading contamination through the water that remains. The rights of the original residents are little protected by the "efficient" market solution.[19]

When urban areas seek unallocated water from distant rivers or aquifers for high-value uses, the market suggests that this is efficient. But, to the localities that would lose water, it smacks of theft—especially if there is a cheaper way to obtain the water. For instance, New York City has long imported costly water from the distant Delaware River, creating a problem with ocean water entering Philadelphia's supply. However, several studies show that the Hudson River, which flows past New York City, would be a cheaper, if less reliable, source, and more efficient in the future than sources even more distant than the Delaware.[20] Similarly, Boston proposes diverting water from the Connecticut River to the disadvantage of western Massachusetts, but the city might meet its needs more economically by recapturing the estimated 35 percent of its water that leaks from transmission pipes. (The national average for such leakage is estimated at less than 12 percent.)[21]

Even when water-allocation decisions balance efficiency and equity considerations, their effect on environmental quality can be politically explosive. Many early water developments in southern Florida, for instance, focused on providing drainage for land so that it could be developed for agriculture or housing. A canal was dug in the mid-1960s to cut off the overland flow of water into Everglades National Park, allowing new housing for several hundred residents to be constructed next to the park. Such projects, however, soon began to create serious problems for the Everglades, which can only survive if its water is continually replenished. The Everglades were also threatened occasionally by heavy releases of stormwater into the park, which previously had been spread across the lands being developed for agriculture and housing. Now, initiatives are underway to fill in the drainage canal, and some stormwater runoff has been redirected to flow across the yards of nearby residents, to their understandable distress.[22] Most Americans probably agree that the ecological survival of Everglades National Park is sufficiently important to not allow a few homeowners to use the park as a local water-regulation basin. However, the Everglades' residents did rely on prior government action—as did the flooded Colorado River valley dwellers—before they built their homes.

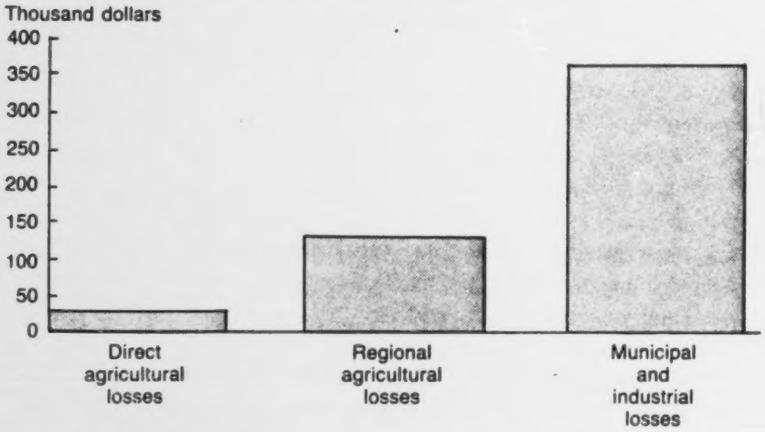
Of course, attempts to solve problems sometimes harm the environment. The energy crises of the 1970s brought in their wake a raft of plans for low-head (that is, small) hydropower dams, primarily on the West Coast and in New England.[23] But when a dam is operated to maximize power (especially peak power) production—requiring dramatic fluctuations in water releases and, hence, lake levels—the results may include serious harm to users of both the dammed lake and the river downstream.

Figure 7.1
Reservoir Storage Reallocation for Washington, D.C., Metropolitan Area


Original allocation of reservoir capacity
Reallocation of reservoir capacity
Flood-control storage, normally left unfilled
Water-supply storage, original allocation
Storage capacity reallocated from flood control to water supply

Source: U.S. Army Corps of Engineers.

Figure 7.2
Economic Costs of Colorado River Salinity, by Sector, 1982



Direct agricultural losses: decreased crop yields, increased water requirements for salt leaching and drainage, increased management costs.

Regional agricultural losses: decreased income to segments of the economy dependent upon agriculture.

Municipal and industrial losses: increased water-treatment costs, accelerated pipe corrosion, and appliance wear, increased soap and detergent needs, and decreased water palatability.

Source: U.S. Bureau of Reclamation.

For example, the townspeople of Swanville, Maine, feared that a new hydropower facility on Swan Lake would destroy the lake's fish as well as their own access to the lake for fishing, swimming, boating, and reliable water supply, and so they intervened in the federal-permit proceeding for the facility. As a result, the permit was not awarded for well over two years after application was made for it—and not until the operator had reached a compromise with the town on lake levels and recreational use. Even then, concern remained that federal jurisdiction over lake operation would enable the operator to abrogate the compromises. In other localities with similar problems, even such tenuous agreements often are not reached.[24]

As the Swanville example suggests, sometimes mutually acceptable compromises between genuinely conflicting values can be struck. However, even resolution leaves these questions: What level of government, if any, decides on water-use proposals, and what interests get to participate in that decision? Is there a means for society to decide whether or not some alternative would be preferable? Who should bear the financial burden of an action—the beneficiaries or taxpayers generally, through government subsidies? The answers to these questions were predictable 15 years ago, but the waves of change that are sweeping across the field of water management are leaving an altered institutional landscape. The "Who Decides?" and "Who Pays?" sections of this chapter explore that landscape in a search for new answers to these questions. Next, however, is a look at one of the most pervasive and difficult problems in water policy today—the relationship between water-quantity and water-quality management—and the powerful but flawed institutional legacy of past solutions to water problems.

The Quality/Quantity Problem

The United States generally has dealt with its two major types of water problems—water quantity and water quality—in different statutes, by different agencies, and at different levels of government. Yet the problems are closely related, and solutions dealing with only one problem often end up exacerbating the other.

To appreciate the quality/quantity relationship, it is essential to understand that pollution is not an absolute concept.[25] Nearly all water is contaminated in some way. Contamination is only a concern when it reaches concentrations that pose a threat to human health or to the uses of water.

The quality/quantity relationship is strikingly demonstrated by the

Colorado River's salinity problems, which have worsened steadily since the 1930s when construction of reservoirs in the river basin began. About half of the salt in the Colorado comes from natural deposits; most of the rest comes from irrigation return flow—water that picks up salt from croplands.[26]

Still, the higher salinity in the river is caused less by greater additions of salt than by consumption of the river's fresh water—water that formerly diluted the salt, keeping its concentration down. Of the 13.5 million acre-feet of average annual flow in the river, some 2.25 million acre-feet evaporate annually from reservoirs in the two basins of the river system; over 750,000 acre-feet are transferred out of the Colorado's upper basin to satisfy the thirst of rapidly growing cities such as Denver, and another 2.1 million acre-feet are consumed in irrigation in the upper basin.[27] Lower-basin diversions which increase salinity concentrations above Imperial Dam, California, just north of the U.S.-Mexican border, include about 950,000 acre-feet diverted to Las Vegas and Los Angeles and several hundred thousand acre-feet for irrigation.[28]

The Colorado's high salinity substantially damages downstream water uses. It depresses crop yields, corrodes equipment, may require costly treatment of water for municipal use, and reduces long-term soil productivity (figure 7.2). Damage is estimated at over half a million dollars for each additional milligram per liter of salt content at Imperial Dam—the increase in concentration that results when 10,000 acre-feet of fresh water are removed from the upper portion of the river.[29]

The Colorado River's salinity problem is a dramatic example of how a single-value water-resource use can impose substantial "externality" costs on users and on taxpayers because decision makers did not consider all relevant factors. In 1974, Congress approved a program to ameliorate the salinity problems that were caused by earlier water-quantity decisions.[30] As part of this program, the United States is building a $234.1 million desalting plant in Yuma, Arizona, to meet treaty obligations with Mexico to deliver each year 1.5 million acre-feet of water with acceptable salinity.[31] The river basin's consumers, of course, pay no more of these costs than do residents of New York or any other region located out of the basin.

Such projects are inefficient, as the then-commissioner of the U.S. Bureau of Reclamation, Robert Broadbent, conceded in 1982 when he testified that "subjecting the Salinity Control Program to a cost-benefit analysis could prevent the units from ever being constructed."[32] Now the bureau and water-development interests in the Colorado basin are finally being forced to come to grips with the need to increase the quan-

Yakima Valley: Dousing the Flames of Conflict

The Yakima River basin in Washington State, known as the "fruit basket of the Pacific Northwest," offers a microcosm of the water-use conflicts and management issues being faced throughout the West and, increasingly, throughout the nation. An arid region located in the "rain shadow" east of the Cascade Mountains, the Yakima Valley owes its remarkable productivity to the energy of its farmers and to the U.S. Bureau of Reclamation, whose projects have liberally watered the valley for over three-quarters of a century. But, following the recent emergence of interests formerly excluded from the competition for water, it appears that the basin's once-lavish water supplies may no longer be adequate if they continue to be managed as they are now.

Yakima Valley farmers are renowed as growers of apples and other orchard fruits. Their hops, for beer, are a major factor in the international hops market. In addition, there has been a recent explosion of grape cultivation for high-quality wines. All these activities have increased pressures to expand irrigated acreage. But the farmers themselves are not a monolithic bloc. Rather, they are commonly divided into "junior appropriators," who mostly are downstream and either have secondary, relatively recent (post-1920s) rights to the river's water, or have benefited from earlier Bureau of Reclamation projects, and the largely upstream "senior appropriators," who have primary, longstanding "natural flow" water rights. The senior appropriators are assured of a full supply of water even during droughts, causing frequent friction between the two groups.

More pressure was added to the already tense Yakima water-allocation situation when, in the mid-1970s, the Yakima Indian Nation filed suit to claim both treaty rights to flow sufficient for a renewed salmon fishery and federal reserved rights for water to irrigate their croplands and supply their homes. The total yearly anadromous (migrating) salmon run on the Yakima had declined from about 500,000 fish before 1880 to a mere 11,000 in the 1920s, a result of offstream diversions and inadequate fish-passage facilities (that is, screens and ladders) at the various diversion dams and hydroelectric facilities along the river.

Sparks ignited the dry tinder of this water competition in 1977 when the Bureau of Reclamation predicted a major drought that would effectively eliminate all bureau-project water deliveries to junior appropriators. Although the drought turned out to be much less serious than predicted (the bureau mistakenly had omitted agricultural return flow from its calculations), many farmers had meanwhile taken such costly steps as purchasing emergency water supplies and transplanting entire fields of perennial crops, such as mint, to the neighboring Columbia River basin. Understandably, the 1977 fiasco spurred congressional and bureau inquiries. Subsequently, the farmers' demand for more storage to stabilize and expand the reliable supply and to meet the Indians' demands won a congressional response in 1979—a federal study of possible new storage, the Yakima River Basin Water Enhancement Project (YRBWEP).

In 1980, the Pacific Northwest Electric Power Planning and Conservation Act contributed still more fuel to the flames when it required that steps be taken to resuscitate the Columbia River salmon fishery, for which the Yakima was formerly a prime spawning ground. Implementation of the Yakima's treaty rights would help, but the addition of yet another claimant to the basin's water competition seemed to some to further justify prompt authorization and construction of YRBWEP.

But gaining that new storage remains difficult and uncertain. As of the spring of 1984, no new water project anywhere in the United States had won an appropriation of funds from (or had been newly authorized by) Congress since 1976. Congress would surely take a hard look at YRBWEP's economics before approving more federal water subsidies to a basin that, relatively speaking, is quite prosperous.

And state environmentalists soon raised another objection to the proposals. The largest single element in the storage project would be the enlargement of Bumping Lake from its current 33,000 acre-feet to 458,000 acre-feet. The enlarged reservoir would back up water into the proposed Cougar Lakes Wilderness Area (now a national forest primitive area) just east of Mount Rainier National Park and would be located adjacent to the settlement of Goose Prairie—the favorite home of the late Justice William O. Douglas, a patron saint of many environmentalists.

Environmental groups sharply criticized the bureau's moves to quickly specify final reservoir sites. Instead, they urged the bureau to prepare "at least one nonstructural alternative as a part of the feasibility study," in fulfillment of the NEPA requirement to consider such options. The bureau, together with the state Department of Ecology, did move to consider the possibility, convening an expert panel in early 1984 to aid in the evaluation of techniques such as water banking, improvements in the efficienty of water use and conveyance in canal systems and on farms, management consolidation, and advanced water supply forecasting and modeling. Such techniques would seem to hold out a promise of easing the basin's water conflicts, although they are greeted with suspicion by many of the existing water users and managers.

What implications does the new openness to these techniques in the Yakima Valley have for the rest of the United States? The interest in using the techniques in the Yakima basin stems largely from tight federal budgets and a growing congressional resistance to further water subsidies, two conditions likely to continue indefinitely. If the technological "fix" of the innovative approaches proves itself in a variety of settings, the means of resolving many present water conflicts across the country could be at hand.

But, while engineers can tell policy makers how much additional water is obtainable through innovative management, those policy makers must in turn tell the engineers how to allocate the water among users. Improved technical administration of water may ameliorate some conflicts, but it will not eliminate the need to address the difficult institutional problems—fragmented management perspectives, unresponsive allocation systems, and wasteful pricing structures—that helped to create such conflicts. In other words, what computer-age technology may have given water policy is at best a breathing space in which to put its affairs in order.[1]

tity of water as a means to reduce salinity; they are supporting an on-farm program run by the U.S. Department of Agriculture to reduce saline return flows and conserve water. As one U.S. senator observed, the more efficient use of scarce western water supplies should be "the cornerstone of the salinity control effort."[33]

In some cases the quality problems can be caused by excessive quantities of water. The drainage of North Carolina coastal wetlands for farming, aided by federal and state agencies interested only in agricultural productivity, has been reducing the salinity of one of the largest estuarine systems on the Atlantic Coast by pouring into it fresh water from the drained wetlands. Faced with the decline of a highly productive and profitable estuarine-fisheries industry dependent on the previous degree of salinity, a gubernatorial task force recommended that drainage practices be limited in a way that would be fair to both farmers and fishermen. In effect, the task force sought a plan that would harmonize economic interests, fairness concerns, and environmental values.[34]

The relationship between quality and quantity is being increasingly recognized as groundwater supplies also become more intensively exploited. If an aquifer becomes contaminated, increased withdrawals speed the spread of the pollution. Similarly, when water is pumped from an aquifer faster than it is recharged (that is, when the groundwater is "mined"), saline water can be sucked in from nearby aquifers or, in coastal regions, from the ocean. Either form of contamination can render the aquifer useless as a continued source of supply.

In recent years, Florida has discovered that a great number of dangerous contaminants—in percolation from waste-disposal sites and in concentrations of pesticides used to protect citrus trees—find their way into its large, shallow, limestone aquifer. Tucson, Arizona, has discovered similarly that it has, for all practical purposes, a closed water system.[35] As groundwater pumping has increased (lowering the water table by 100 to 250 feet in 35 years),[36] a number of contaminated sources have threatened the city's aquifer, on which the city depends for survival. The heavy pumping has caused dumped wastes of the toxic chemical TCE (trichloroethylene) to spread into a six-mile plume in the aquifer, forcing the closure of 23 wells and posing a threat to at least 60 more.[37] Because of periodic floods, heavy metals and landfill pollutants are recharged into the groundwater. Leakage from tailings ponds of copper mines south of Tucson percolates into an area with domestic and municipal wells.

Such areas are finding that there is no clear-cut distinction between

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water-quality and water-supply problems. Their situation is not unique, and there is every reason to expect that it will become more commonplace in the next few years. Groundwater pumping nationally went up 76 percent from 1960 to 1980, and total consumption of both groundwater and surface water increased nearly 64 percent over the same period.[38] Concerns about the implications of increased consumptive use of fresh water in the Chesapeake Bay watershed has led at least one Maryland state official to fear that "all of our water quality ... control steps would be rendered ineffective."[39] Thus, as more water supplies are consumed, pollution from poorly controlled sources—waste and dump sites, farm and urban runoff—will become far more serious.

Institutional Reflections

Governments do not ordinarily act comprehensively to remedy a major problem. More commonly, as was the case with the Colorado River's salinity, a statute is passed initiating a new program to deal with the most obvious or politically sensitive aspect of the problem. The eventual result—as demonstrated in chapter 6—is likely to be a patchwork of often inconsistent laws dealing with different facets of a larger problem and working at cross purposes. In this way, the institutions created to deal with some water problems may first embody one generation's preferences, may later cause other water problems, and may end up complicating the search for comprehensive solutions.

Most of the reasons for institutional conflicts are understandable. All sides of the so-called iron triangle—legislatures, bureaucracies, and interest groups—seek to fit new programs into the mold of existing processes, legislative jurisdictions, and agencies.[40] At the federal level, interest groups "with a conscious, specialized stake in Washington," join with well-placed legislators and "the bureaucracy [to put themselves] either in control of or in a strong bargaining position vis-a-vis the gamut of values at stake in national policy making."[41]

These different interests have succeeded in splitting water-development authority among different federal agencies—the Bureau of Reclamation, the Army Corps of Engineers, and the Soil Conservation Service—each of which caters to the desires of its particular constituency. Water pollution programs were placed in the Environmental Protection Agency (EPA) with little meaningful coordination or sharing of missions between it and the other agencies. This fragmentation of power is often duplicated in practice, if not by administrative structure, at the state and local levels—in part, stimulated by a need to mirror the federal structure of grants and mandatory programs.

The same concern for turf protection and other self-interest that generated the one-track problem-solving approach creates an inertia in the participating groups that is very difficult to change.[42] The difficulty in applying cost-benefit analysis—a technique to evaluate the economic efficiency of a project and, potentially, to lay bare its real purposes and inadequacies—to federal water projects is an extreme example. Though such analysis was first required for some projects, strenuous resistance from all three sides of the iron triangle prevented cost-benefit analysis from being made mandatory throughout the government until 1979, when it became part of a continuing effort to integrate efficiency, equity, environmental quality, and regional economic development into a formal project-planning process for all federal agencies.[43] The Reagan administration, however, backtracked in 1982, when it reverted the guidelines to a voluntary status and abolished the interagency Water Resources Council that led the fight for consistency, rigor, and integration within the federal government.[44]

Thus, there tends to be limited support for the more sweeping integration of quality/quantity solutions across agency boundaries: such integration is relegated to politically impotent regional planning and river-basin organizations, if it is addressed at all. As a result, the single-focus-agency approach to quality/quantity issues may fall short on all three goals of efficiency, equity, and environmental quality. The Colorado River salinity example suggests how fragmented decision making forces society to pay twice to solve quality/quantity problems: once to reach the original supply or cleanup objective and once again to deal with problems created by the first "solution."

It is also difficult to contend that single-aim programs provide socially equitable benefits. Programs to build storage dams and other water-supply projects seemed sensible in their earlier years, with their aim to redistribute resources to regions (for example, the West) and social groups (for example, small farmers) that were otherwise disadvantaged. But, over time, some of the formerly disadvantaged have become rather privileged.[45] Besides, water-development programs in practice have not always provided as much help for the poor as intended. For instance, although 91 percent of the landowners receiving irrigation water from the Bureau of Reclamation own fewer than 160 acres (the size limit set in 1902 for irrigation subsidies), under 3 percent of the farms control 31 percent of the land served by bureau projects.[46]

Finally, federal agencies are being forced to recognize that single-mission water policies are often detrimental to environmental quality. The U.S. Army Corps of Engineers was among the federal agencies most frequently sued for failure adequately to consider environmental concerns in their proposals in the first years after the National Environmental Policy Act (NEPA) was passed.[47]

Options for Integrated Solutions

One approach to the quality/quantity quandary is to take direct steps to reduce fragmentation and spur closer integration of the two issues. In fact, numerous measures have been adopted, primarily at the state level and primarily in response to specific local conditions and issues. This contrasts with the way in which federal regulations, grants, and projects often have forced state and local actions into the same mold, regardless of local suitability. Some of the possibilities of these integrated programs, and their difficulties, are discussed below.

Formal Requirement to Consider Effects of an Action. This option represents the least change from business-as-usual. It was instituted throughout the federal government by NEPA and many similar state laws that require some sort of impact-assessment process.[48] Although denigrated by many as relatively trivial, these laws marked a historically significant rejection of compartmentalized decision making by requiring agencies comprehensively to assess the effects of their proposed actions.

However, impact assessment alone is not sufficient to merge water-quality and -quantity goals in agency decisions. Unless an agency has the authority to act on such broader considerations—and reap institutional benefits from doing so—it is not likely to take them into account to any significant degree. The behavior of the Tennessee Valley Authority (TVA) in pressing for completion of the Tellico Dam in Tennessee is illustrative. TVA's actions suggest that the loss of agricultural land and of fish and wildlife caused by the project (which, even from the standpoint of direct costs alone, was uneconomical) were not compelling considerations to TVA, because its statutory mission was limited to flood control, power production, and economic development.[49] The project's local and congressional backers, the other two sides of the iron triangle, shared the same narrow concerns. Mere information and argument generally will not force such groups to recognize broader views.

Institutional Coordination. If simple consideration of effects does no more than raise agency awareness—with limited hope of corresponding action—then perhaps a structured liaison among agencies can be more effective. At the federal level, an interagency memorandum of understanding is the typical method for making coordination formal, but historically this device has been weak unless applied to specific, active projects or to statutes that demand coordination.[50] One interesting state initiative illustrates a pertinent principle.

Minnesota has established a coordinating council, the Groundwater Protection Strategy Work Group, comprised of key staff from the 13 major federal, state, and local agencies responsible for particular aspects of groundwater management. Although the group has no power of its own and operates fairly informally, the political premium that Minnesota citizens place on the plenitude and purity of their water apparently induced the members to seek substantive management agreements to protect groundwater quality and supply and to implement those agreements in their respective agencies. Similar arrangements to coordinate the actions of different water agencies are proposed in Mississippi and Wisconsin, although they are not likely to be as effective unless their state's residents and governor have the apparently strong political commitment to coordinated management that enabled the Minnesota group to be effective without formal statutory authority.[51]

Broader Statutory Mandates. Another alternative being used with increasing frequency is to broaden agency objectives by statute—that is, to permit an agency to consider and act upon wider concerns. One type of provision adopted in several states encourages agencies to act on the commonsense proposition that it is efficient to match an available water supply with users who need water of that quality.

In Florida, for instance, new industries that do not require high-quality water are strongly urged by statute to locate at coastal sites where abundant quantities of briny water can be supplied, leaving inland fresh water for domestic and agricultural needs.[52] Similarly, several localities around the country, some under statutory mandates, use treated effluent from municipal wastewater plants on public golf courses, on farmland, and for the recharge of groundwater supplies.[53] The motivating factor in most of these cases is probably economics. Where "new" supplies are very costly, wastewater already in the system may be the least expensive source of supply.

Administrative Consolidation. The ultimate logical step toward integration is to combine quality and supply responsibilities in the same agency. Such an administrative consolidation seems desirable in principle, but a half-century of failed attempts to establish a unified federal Department of Natural Resources suggest the unlikelihood of creating a federal Department of Water Resources.

Even in the state "laboratories of democracy," where such consolidations have been tried, the results have varied widely. In Washington State, a 1970 consolidation of quality and quantity functions (which had been in two separate, potent bureaus) into a single Department of Ecology was to some degree undone in late 1983, even though, at the beginning, the consolidation had been taken so seriously that many staff members of the original agencies exchanged duties.[54] The reversion was impelled, at least in part, by the state legislature's desire to see specific functions administered individually in a familiar bureau—possibly another example of the iron triangle at work.

More recently, South Dakota successfully combined two active water agencies because of strong gubernatorial prodding and probably because the issues of salinity and effluent reuse were important to both quality and quantity constituencies.[55] Iowa, Mississippi, and Tennessee have each merged a largely advisory or untested water-quantity function with a more dominant water-quality function within the last five years.[56] Although some fear that the smaller quantity function will get short shrift in appropriations and program visibility, in a larger agency it may be better placed politically and substantively to expand if water allocation becomes a hot political issue nationwide.

Evidence of consolidation's clout is apparent in the experience of New Jersey. An ability to deal with severe pollution threats to the state's urban water supplies—and with the lust of Philadelphia and New York City for the vast, pure aquifers of New Jersey's Pine Barrens[57]—has shown the benefits of the integrated review of all water permits that is routine in the state's consolidated Department of Environmental Protection.[58]

Thus, a few states with combined water agencies seem to have put an integrated operation into place, although no such program has really been tested over the long term. But, even when organizational obstacles can be overcome, the possible costs of restructuring, including program disruption (as Washington State's consolidation illustrates), must be recognized. However, a clearly warranted and well-designed consolidation should produce long-term improvements in water policies and program operations that outweigh any short-term costs.

A more serious, seemingly permanent, drawback to integration is that tying water-quantity management more closely to that of water quality makes it more difficult to integrate water-quality programs with air and solid-waste regulation (as discussed in chapter 6). Ending management fragmentation in one problem area may often cause it in another.

Whether consolidation is desirable depends largely on whether it is functionally practical, politically realistic, and appropriate to local conditions. Without these ingredients, consolidation is unlikely to be worth its costs; in such situations, it seems preferable to reduce fragmentation in water management by the other, less drastic means of broadening statutory mandates and coordinating existing institutions. In any case, the most important thing is to have enough administrative coordination to find harmony when a conflict is not irreconcilable (as in the North Carolina drainage case) and to at least recognize the different points of view in a genuine conflict (as in the Everglades flooding).

Concluding Thoughts

The quality/quantity examples discussed here generally appear to involve relatively straightforward relationships between depletion and contamination, but whether these relationships always hold is not known. Despite all the complexities of the administrative adjustments evaluated above, it is easier to suggest such adjustments than to define the actual physical principles that link water quality to water quantity and should guide bureaucratic practice. These principles can be found only through further scientific study, and such study can be gained principally by observing how integrated agency practices and decisions actually affect a physical water resource itself—a sort of Catch-22 situation. Nothwithstanding this uncertainty, a greater degree of integration remains desirable where it can be obtained.

WHO DECIDES ON WATER USE?

In 1976, a farmer named Joy Sporhase started using water from a well on his farm in Nebraska to irrigate some land he owned in Colorado, just across the road. He had been barred from drilling the well in Colorado itself because the land overlay part of the Ogallala aquifer, which was subject to heavy overdrafts and strict control of water withdrawals.[59] Like many states, however, Nebraska had a statute strictly limiting the export of water. It therefore demanded that Sporhase cease piping his Nebraska-drilled water into Colorado. He refused and vowed to defend his position to the limit.

The resulting 1982 U.S. Supreme Court decision—*Sporhase* v. *Nebraska ex rel. Douglas*[60]—shocked the West and has striking implications for the rest of the United States as well: the court held that Nebraska's statute limiting exports was an unconstitutional restriction of interstate commerce in water. If the decision is broadly applied, it could greatly limit states' power to control interstate transfers of water, especially from farms to cities and industries.

The increasing competition for scarce water resources is already stimulating such transfers both within and between states. Today, the challenge for water policy is to resolve these conflicts through sensitive and careful planning and management. This makes the question of *who* resolves the conflicts increasingly important.

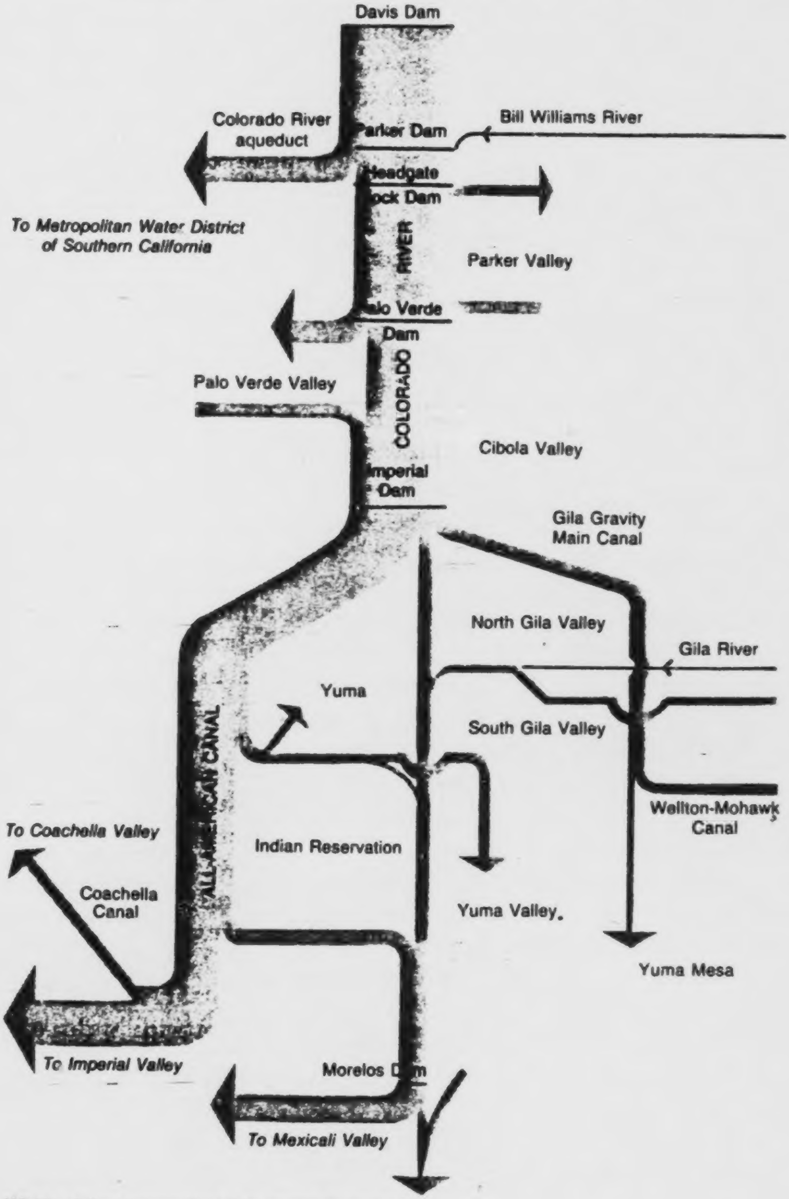
In the past, it usually was possible to settle such conflicts simply by developing new water supplies.[61] But, with tighter supplies and tighter money, it will be increasingly difficult to apply such solutions in the future. To supply new claimants, more water will have to be squeezed out of existing supplies by conservation, better management, and, in some cases, transfers from present users. With greater demands on scarce water, will decision makers be able to balance wisely and fairly the demands for efficiency, equity, and environmental quality in water use and allocation?

Growing scarcity and market competition for water are not the only factors changing the traditions of water allocation. As the last drop of water is wrung out of western river systems such as the Colorado's (figure 7.3), and as new industrial and municipal users place unprecedented demands on watersheds in other parts of the country, protests are being raised about reduced water levels and the loss of various resources and activities—riparian and in-stream habitat for fish and wildlife, swimming, boating, fishing, aesthetic values, and the like—that depend on more generous stream flows.[62]

Laws designed to keep water in rivers often are enacted in response to such protests, but, in reality, they set the stage for increased allocation conflicts between in-stream and off-stream competitors. In addition, in many western states, the water claims of American Indian tribes add still another layer of confusion to the water-allocation picture. Many tribes are seeking rights to water as a resource reserved to them along with their reservations, and the amounts claimed may exceed available stream flows.[63] It is clear, in any case, that the varied claimants all want to be included in the decision-making process.

In the arid West, the first region to face full-scale competition among all types of users for a fully allocated water supply, watching the development of a slow but irresistible wave of change is particularly illuminating. The traditional interests—farmers, ranchers, miners, and their lobbyists and allies throughout the government, who long defined the rules under which water was used—are now facing the mounting influence of other

Figure 7.3
Average Annual Water Flow in the Lower Colorado River



Width of line proportional to average annual flow.

Source: U.S. Geological Survey.

groups such as American Indians, Hispanics, environmentalists, and tax payers associations, in water decisions.

In Arizona, passage of the sweeping 1980 Groundwater Management Act[64] marked the decline of farmers' influence over water allocation and the ascendancy of urban interests. An alliance of traditional user groups in California failed, in 1982, to win voter approval of the state's controversial Peripheral Canal project.[65] In New Mexico and Colorado, special commissions on water law and allocation appointed by the governors have included as members several persons not identified with traditional water interests.[66] In Congress, the emergence of new voices and values has brought a slowdown in the authorization of new projects since 1976.[67]

Water-quality decisions provoke less debate than water-quantity decisions about which constituencies should be involved, probably because the Clean Water Act incorporates public participation. Few decisions can be made without a public hearing or public comment, and those comments go on the record that is used to interpret the law. Thus, no one interested in the issue is excluded.

But the water-quality programs have stimulated substantial debate about which level of government should have primary responsibility to decide.[68] Before 1972, this authority clearly rested with the states or, if they did not exercise it, with local governments. However, the 1972 amendments to the Clean Water Act transferred much authority to the federal government, although it could be delegated back to the states if they demonstrated the capability and willingness to accept it. To regain control, the states had to implement the uniform, national, technology-based effluent limitations set by the federal government. Even then, the feds would look over their shoulders.

In the last few years, the question of how much independence states should have has been debated even more vigorously. When the former EPA administrator, Anne Gorsuch, attempted to give the states greater flexibility in setting ambient water-quality standards, the Senate's Environment and Public Works Committee resisted the move until her successor, William Ruckelshaus, relented.[69] Similarly, a long-standing controversy over who should have primary responsibility for controlling toxic waste discharges into municipal sewers—the municipality that owns the sewers, the state, or EPA—was settled in favor of EPA.[70] These results reflect both a concern that too many states and municipalities are unable or unwilling to exercise effective control over problems that affect their economic growth and a judgment that EPA is better situated politically to deal with such problems.

Interstate Conflicts

The specter of *Sporhase* is threatening to many states because the case could undermine their authority to control their water resources and the economies that rely on them. *Sporhase*-authorized interstate water transfers promise to give government less, and the water market more, control over water allocation. The West has had a quiet market in water rights, but the rapidly growing populations and large energy companies there can afford to pay very high prices for water rights—prices so high that many farmers growing low-value alfalfa are sorely tempted to sell their rights. This market already is becoming more competitive and volatile. But, even as the competitive pressures that create intrastate water conflicts spill over state lines, the *Sporhase* decision puts state power to deal with interstate conflicts in a sort of limbo.

The first major post-*Sporhase* decision, *El Paso* v. *S. E. Reynolds*, strengthens the concept that state export limits are impermissible.[71] The city of El Paso, Texas—which sought to pump water from the Mesilla Bolson (aquifer) of southern New Mexico as its own supplies became depleted—successfully contested, at the federal district court level, New Mexico's absolute ban on water exports. The court held that *Sporhase* prohibits any export limits other than those that protect the few gallons per day necessary for the "survival" of a state's residents.

Many states are probably largely unaware of *Sporhase*—witness the recent proposals in Michigan to bar any out-of-state water exports.[72] Officials in other states, particularly in the East and South, may assume that *Sporhase* does not apply to their states. But those states may well be proved wrong if they too attempt to limit water exports because of feared local shortages and increased interstate competition that might negatively affect their economic futures. Local protectionism may be a two-edged sword. While New York City longs to store and divert the headwaters of the Susquehanna River—which flows completely across Pennsylvania and is the main freshwater source of the Chesapeake Bay in Maryland—New York State goes to court to restrain Exxon's diversion of Hudson River water to Aruba by oil tankers.[73]

Interstate disputes on the Apalachicola River system (in Georgia, Alabama, and Florida), the upper Missouri River, and the Connecticut River—between municipal and industrial supply and in-stream flow for water quality, navigation, and fishery protection—illustrate that these conflicts affect all parts of the nation.[74] The inexorable pressure throughout the United States for interstate water diversions to support municipal and industrial development will continue to erode unilateral state attempts to control water resources within state boundaries. Indeed, state autonomy over river resources had begun to fade even before *Sporhase*. As one state official commented, "although the States in their constitutions and statutes claim ownership of the water resources within their boundaries, the development of those resources tend to be out of State hands."[75]

The diminishing of interstate water-quality disputes over the past decade by uniform national effluent standards may just be a temporary calm, as states find out-of-state sources responsible for some of their nonpoint-source water pollution. Maryland has discovered already that much of the pollution entering Chesapeake Bay comes from Pennsylvania. Canada clearly has a major stake in the Great Lakes, but a large part of the pollution there results from the United States' failure to further clean up Great Lakes waters as directed in binational agreements.[76]

Among the obstacles to resolving interstate water disputes over quality or quantity, the first and most obvious is simply geography. Few major river systems are contained within a single state; the common use of rivers as state borders guarantees conflict over water allocation and use. Only three state borders in the entire nation—Montana-Idaho, North Carolina-Tennessee, and Virginia's western borders with West Virginia and Kentucky—follow watershed lines for any significant part of their length, and no border does so in its entirety.

Another obstacle is the quality/quantity issue: troublesome under any conditions, it becomes particularly so in interstate conflicts, as in the case of the Colorado River's salinity. Sometimes, quality problems are so intractable they are simply ignored in allocation agreements, which may lead to difficulties later. Sometimes attempts to avoid quality problems lead to supply disputes. This was the experience of El Paso when it turned to the aquifers of southern New Mexico as an alternative to increased pumping of its own groundwater because such pumping would have caused saline intrusion from deeper, poorer-quality aquifers.[77]

Conversely, several factors promote resolution of interstate water conflicts. Any state has the potential to lose as well as win from interstate transfers, particularly if a state shares watersheds or groundwater aquifers with other states. If states recognize this mutual vulnerability, *Sporhase* may stimulate them to cooperate more aggressively in interstate agreements. If states see that they cannot control the water demands of out-of-state users (ranging from cities to mineral or energy developments in remote, rural settings) by themselves, they may seek to limit those demands in concert with other states and Congress. New and more flexible interstate agreements may emerge from this turmoil.

Similarly, federal budget constraints, under which states are forced to share water-development costs with the federal government, create incentives for states that share a common water body to find cost-effective interstate plans for water development and treatment.

Intrastate Conflicts

Although it is perhaps ironic that a lawsuit involving a lone Nebraska wheat farmer could open the floodgates for such a tidal wave of change, the emergence of this dispute now is not a historical fluke. The same water scarcities that caused Colorado to prevent Joy Sporhase from drilling a well on his Colorado farmland are becoming common not only in the West but throughout the United States—and for both groundwater and surface water.[78] The U.S. Geological Survey identifies water availability and, implicitly, the "rising competition for water" as "an issue in every state" and one that is in fair part "a function of the facilities and the institutional arrangements—laws, agreements, and operating rules—for withdrawing the water."[79]

In eastern states, where conditions of water surplus have long been routine, the very definition of water rights, not to mention their quantification and transferability, often has been left quite vague. But with growing demands for inland navigation and irrigation water in the South, for flows to dilute pollution in the North and Midwest, and for municipal and recreational water everywhere, this vagueness is not likely to be politically, economically, or socially tolerable for long. As the Geological Survey noted, "although the competition grows gradually, the resulting scarcity may develop ... suddenly."[80]

Most western states have passed this stage and are in more serious straits. Shortages in some areas are so severe that mandatory water-conservation programs are being imposed for all types of users; in other areas, the cost of extending wells to rapidly receding water tables is leading many farmers to practice conservation and even causing some to reduce the amount of irrigated acreage.[81]

However, neither the western appropriation nor the eastern riparian system of water allocation was designed to resolve competition among users and claimants. Appropriation tends to prefer existing users, while the riparian system fails even to provide a clear mechanism for accommodating competition. The appropriation system requires proof that water-right transfers would cause no harm to third parties. In states under riparian law, water use must be "reasonable,... adapted to the character ... of the stream," and "fair ... [as] between [the user] and his neighbor."[82] Both legal doctrines were well-adapted to their time and purpose of stimulating new water-resources development but—like federal subsidies of regional growth—they may have outlived their usefulness.

This is particularly clear in eastern and southern states, where there often are no tools, or only rudimentary tools, for states' water administration. Often, no mechanism exists to clarify rights to water. In addition, deep-seated political traditions of local autonomy in these states sometimes make effective statewide or regional management of water supply difficult or impossible.[83] For example, when the city of Virginia Beach, Virginia, tried during a 1980-81 drought to acquire groundwater rights from neighboring localities, it was unsuccessful largely because no system of rights transfer existed to define the process and allay local fears. As a result, when the city thereafter sought to find a long-term water supply for its booming population, it decided to spend $180 million for an 85-mile water-supply pipeline to a distant reservoir rather than deal with the uncertainties involved in trying to obtain cheaper groundwater rights from its neighbors.[84]

For western American Indian tribes, the process of defining their own water rights has been particularly troublesome. These rights traditionally were quantified by courts, not states, although the relatively sizable allocations some tribes received on paper through litigation were rarely followed by the financial assistance from Congress that generally is necessary to bring "wet" water to Indian lands. While some tribes have won significant victories by litigation, other tribes have decided to explore a more direct role in managing water resources and to try to secure actual water supplies through negotiation. Some advocates of negotiation argue (not without reason) that that process offers the Indians the best deals they could get, but others are not so sure. Negotiations often may be structured from the start to assure continuity of water supply for non-Indian economic growth and may thereby diminish the breadth of tribal choice on the use of their water. Tribal participation in the settlement process thus may be less meaningful than it appears to be. Accordingly, the settlements sometimes grant water on terms that sharply restrict its use, terms that may press the water toward uses that the Indians lack the time to consider fully and that many Indians do not find to be in their best interests.[85]

Even if such cases are settled, much conflict may remain—between tribes that lease their rights and want to control the uses to which the leased water is put and states that want to mold the use of water in the local economy and to administer Indian water rights within existing systems.[86] This may require states simultaneously to become more sophisticated in gathering data and analyzing water use and to accept more flexibility in controlling water use within state boundaries.

Meanwhile, water-quality conflicts also will intensify within states. Controls on point-source discharges to surface waters (from such sources as industries and municipal sewage systems) are being installed, but (as is indicated in chapter 2) many stream segments still will not attain standards. Should states change the standards or require increased abatement from point sources? Or should states attack problems, such as runoff from agricultural land and urban streets, that have been too controversial and complicated to take on in the past?

In addition, the pollution of groundwater is becoming more serious. Groundwater contamination is difficult to prevent, and, in most cases, is very expensive to clean up. While some states are moving to reduce nonpoint and groundwater pollution, many are not, and there is growing support for federal technical and financial aid to spur nationwide action. If this limited federal role develops, will it stimulate adequate state and local pollution-control responses, or will pressure grow for direct federal intervention in these two problem areas, which are frequently tied to traditionally local land-use decisions?

Mechanisms for Deciding

Thus, the relatively straightforward conditions of past years—supplies that were generally ample for all comers and quality problems that were thought to be restricted to industrial discharges and municipal sewage—are gone, and traditional systems of allocation and interstate coordination may not be adequate for making decisions. What, then, are some possible decision-making mechanisms, and how do they help balance efficiency, equity, and environmental quality?

In assessing different mechanisms, it is necessary to understand that all water claimants, new and old, have important social precedents on their side. Municipal and industrial users, who can best afford to apply their water efficiently and, therefore, set the market price, stake their strongest claims on efficiency. The role of equity can be raised persuasively both on behalf of Indians with historical claims to water but little history of use and on behalf of the rural poor (particularly in Hispanic or Appalachian communities), who have long-standing but often unquantified rights and are least capable of defending them against outside incursions. Even more affluent farmers who can better afford to defend their rights may on occasion find their traditional life-style threatened as their neighbors' sale of water rights for nonagricultural use erodes local farm economies. And in-stream flow claimants can raise valid concerns about environmental quality. Any new market or other allocation proposal that does not explicitly attempt to balance these three competing goals can be expected to fail.

Historically, both the riparian and appropriation systems of state water allocation were regulatory in nature. And, because these systems were developed and interpreted to provide investment security for the principal water-using groups in each region, both systems resist the changes in water use that are being demanded. But some changes are clearly necessary, and some nontraditional allocation systems are being discussed. Any new system will require some degree of regulation to establish the rules under which the system will act. However, the fundamental choice will be among an essentially regulatory and administrative process, a negotiation and mediation approach, or a market concept.

Regulatory Approach

Existing allocation systems in many states take a regulatory approach in theory, but in practice they are rendered incoherent by many antiquated provisions, particularly the obstacles to transfers. Some observers argue that confusion and bureaucratic narrow-mindedness are inherent in all regulation because public-sector managers lack individualized, market-based performance incentives;[87] others find this criticism of the bureaucracy largely theoretical rather than based on reality.[88] And, as noted earlier, the market mechanism alone historically has been weak in evaluating net social benefits of an action, including those of fairness and environmental quality.

Arizona's 1980 Groundwater Management Act represents the closest thing to a comprehensive regulatory approach. It requires inventories of available groundwater resources, sets a long-range goal of sustained yield from aquifers, and gives the state government the authority to specify how much water each user group can consume and to reduce those allocations (without compensation) as necessary to fulfill that goal.[89] Both supporters and critics of the new law agree that the administrative burden of planning, monitoring, and enforcing such a comprehensive water-use structure is immense, and the Arizona state agency responsible has already complained of having less than half the necessary staff for the task.[90]

As an alternative, the state might have been an opportune place to experiment with a pure system of private groundwater rights, but politicians were apparently unwilling to let the farmers—the predominant rights-holders—capture the entire wealth that such a market would have created. Instead, Arizona adopted a regulatory approach that requires water conservation. This approach deals with equity concerns by requiring that all groups share in water-use reductions.[91] It is, however, too early to tell whether this approach (in conjunction with massive new water imports) will allow Arizona to reach its goal of sustained yield.

Regulatory approaches also are used in interstate conflicts. Equitable apportionment is a process whereby the U.S. Supreme Court takes original jurisdiction over water suits among litigating states by assigning shares of a disputed river flow to them.[92] Such an apportionment typically is based on such factors as past water use, potential for future water development, and extent of the watershed located in the respective states. Although some criticize apportionment as being an inadequately informed judicial interference in a fundamentally political issue, a more serious shortcoming is that apportionments only settle existing claims to amounts of water and provide no means for avoiding or resolving future disputes.

A different way to ameliorate interstate friction over water, which was extensively discussed and strongly advocated by the National Water Commission, is federal legislation that allows states to create federally chartered regional corporations to undertake some water-resources operations.[93] Such corporations principally would bring cost-effective coordination to the water-supply and wastewater-management activities now split among federal, state, and local governments; place some limited authority for these activities at the same regional level as planning by a river-basin commission; and, not least, create a background of positive accomplishments that might spur the participants to reach a more difficult consensus on policy.

Territorial jealousies undoubtedly would create obstacles to this approach, but charter authority should only be sought in cases where there is a clear consensus on regional need. At any rate, supra-local authorities may prove able to obtain such operational functions more easily than they can win regulatory powers, which tend to be retained at the state or local levels.[94]

Negotiation

John Folk-Williams, an astute observer of the western water scene, recently noted that "increasing competition for a scarce resource is causing more and more groups to look for settlement methods less costly or protracted—and better suited to deal with on-going management issues—than litigation."[95] Several notable attempts to negotiate settlements to water disputes have occurred in the past three years. For instance, a multi-interest state task force was established in New Mexico to develop agreements on what methods should determine the effects of mining on groundwater systems. In Colorado, 31 elected officials and private citizens from both sides of the Continental Divide reached agreement in April 1983 on principles to guide plans for meeting Denver's future water needs. In Utah and Montana, state officials and Indian tribes have negotiated water-resource compacts, and in Nebraska water users and environmentalists have been negotiating ways to protect minimum stream flows while allowing interbasin transfers.[96]

Other water-related issues that have been settled through negotiations or mediation include a nutrient-control plan for the Patuxent River in Maryland, several low-head hydropower permits in New England, and large-scale hydroelectric disputes such as the proposed Storm King pump-storage project on the Hudson River and the proposed raising of the Ross Dam on the Skagit River in Washington State.

For interstate waters, negotiation is a better established technique. States may negotiate and agree among themselves on the allocation of water in a basin and on the principles and procedures governing conflicts.[97] When such agreements are ratified by Congress, they become legal compacts with much of the force of federal law. But, while compacts allocate rights to river flow and generally set out procedures for resolving disagreements, they rarely set up institutions independent of the signatory states to aid in carrying out the compact. Quantitative allocation is merely a first step in settling interstate water conflicts; follow-up implementation mechanisms also are essential.[98]

A broader approach, which could in theory provide such a mechanism either by itself or in conjunction with compacts or apportionments, is the establishment of an interstate river-basin commission. Two commissions, for the Delaware and Susquehanna river basins, were established by specific act of Congress and the participating states.[99] Also, Title II of the Water Resources Planning Act of 1965 conferred general authority on states to set up interstate river-basin commissions with both federal agency and state membership. This authority has been used six times, although former interior secretary James Watt eliminated federal funding for these commissions in 1981, effectively abolishing most of them.[100]

Most Title II river-basin commissions operated in the absence of any type of interstate water allocation; they had little or no independent authority and were largely concerned with the preparation of basin-wide water-management plans to coordinate with federal plans. They reflected the understandable reluctance of states to relinquish any meaningful part of their powers to an uncontrollable entity of doubtful competence, political sympathies, or permanence. (Historically, the political authority of regional or interstate governing bodies in the United States has been allowed to grow no further than was absolutely necessary.)

In fact, of all the interstate commissions, only the Delaware River Basin Commission (DRBC)—a body created in 1961 by the need to implement the U.S. Supreme Court's 1954 equitable apportionment of the Delaware River—has been effective, allocating water in its metropolitan region through times of plenty and of intense drought.[101] However, many observers feel that the DRBC's performance has been less effective in dealing with water-quality problems and intrabasin fairness issues raised by water diversions. Perhaps, this reflects the narrowness of the apportionment issue that led to the DRBC's formation.[102]

As with the institutional remedies for quality/quantity fragmentation, political and legal power such as that possessed by the DRBC encourages, but is not always essential for, a successful interstate body. The Interstate Commission on the Potomac River Basin (ICPRB) is a purely advisory entity with no regulatory or developmental authority of any kind. Nonetheless, its sophisticated modeling and research on the most efficient ways to meet the water supply needs of the Washington, D.C., metropolitan area were critical in convincing state, and local governments that agreeing to cooperate would be to their common advantage.[103] Elsewhere, even since the termination of federal support for the Title II river-basin commissions, states in at least one basin (the Missouri River's) have minimally funded their commission to act as a communication medium and to retain a means of generating regionally defined solutions if major conflicts emerge.[104]

Attention to regional problems on the ICPRB model might be a more fruitful outlet for commission efforts. Indeed, if the states themselves want to structure commissions to be more responsive to regional imperatives, they might also consider creating interstate water tribunals or mediation services within such bodies to contain, negotiate, and resolve interstate water disputes within the region.[105]

Negotiation does not always work, either in setting specific disputes or in coordinating interstate interests, particularly if one of the parties has nothing to gain from an agreement. For instance, this give-and-take approach, which was the basis of the nation's water-quality improvement efforts before 1972, was so ineffective that Congress adopted strong federal standards in the Clean Water Act Amendments. Under the pre-1972 laws, no real penalties existed for dischargers who ignored the negotiation process.[106]

Markets

Reacting to the intractability of most existing systems for the transfer of water rights, some commentators press for the creation of entirely free markets in such rights, permitting the value of water (and presumably the efficiency of its use) to rise unhindered by political obstacles to transfer or by preferences for the retention of certain uses.[107] For example, with respect to groundwater, free-market proponents contend that the definition of private rights to extract specific quantities of water would prevent the kind of free-for-all exploitation of this common resource that often has turned renewable aquifers into nonrenewable ones. Proponents claim that the market would protect environmental values as well.[108]

However, a completely free-market system probably would be inconsistent with basic hydrologic principles. For instance, if market transfers were allowed to take pumping operations spread throughout an aquifer and concentrate them in one corner of that aquifer, it could seriously interfere with neighboring pumpers and greatly reduce groundwater flow to surface streams. A straightforward, but still market-based, corrective to this weakness was adopted in New Mexico, where rights transfers are administratively simple but are contingent on a lack of damage to other surface-water or groundwater rights-holders.[109] Moreover, New Mexico's formula respects the equity value of future generations by barring the mining of water (that is, pumping in excess of recharge) in rechargeable aquifers.

Despite the New Mexico scheme's flexibility and responsiveness to change, those who participate must conform their activities to its demanding legal and technical dictates. Moreover, the elaborate, expensive proceedings used to quantify rights in such a system often are far beyond the means of the rural poor. Case studies in northern New Mexico indicate that the organizational requirements needed to benefit from state or federal water projects—like the establishment of irrigation districts with pooled water rights—may be incompatible with the community structures of historic cultures and may be feared as an attempt to "disenfranchise" small rights-holders (see box on Hispanics, Indians, and Anglos).[110] Is there a tenable middle ground between such equity considerations and the efficiency demands of urban and industrial users who seek new supplies of water? The question is not restricted to New Mexico; it arises whenever poor, rural water claimants (such as American Indian tribes) are forced to contend with the water institutions of the mainstream culture.

The New Mexico scheme also lacks any means to protect or retain water flows in-stream. This is a weakness even in the eyes of some market advocates, who argue for the rights of private citizens or organizations to buy and sell in-stream flows on the model of English fishing rights.[111] In light of the inadequacy of many current state programs to protect in-stream flows in the United States and the relatively easy manner in which private rights to in-stream flow could be integrated into the allocation systems of existing appropriation law, such a market proposal might make sense as a supplement to state protection programs. However, in many rivers with complex water-use patterns, private rights-holders alone could have great difficulty trying to monitor and enforce in-stream rights against competing and often hostile off-stream water users.[112]

If a water market on the New Mexico model does develop in other states, it surely will be accompanied by demands to moderate its narrow orientation to efficiency. Already, market competition among water uses in many states has brought demands for state action to protect existing uses and life-styles that are dependent on water. The resulting conflicts between equity and efficiency have created some strange political bedfellows. Conservative Wyoming and Nevada ranchers, who sought divestiture of federal land to the states and furiously battled local environmentalists in the process, have joined those same environmentalists in opposing water allocations for coal-slurry pipelines and MX missile systems.[113]

The market concept also offers an intriguing solution to some interstate conflicts. If interstate rights granted by compact or apportionment could be sold or leased among states in a basin, in the same manner that intrastate water rights of private owners along a river are transferred, it would increase the flexibility—and thereby both the efficiency and the fairness—of interstate water allocations.

Leases of such rights would be beneficial for several reasons. The incentive of states to press for economically inefficient water projects

Hispanics, Indians, Anglos: A Struggle over Water Rights

A particularly poignant illustration of the conflicts among water-use values is being played out in the Pojoaque Valley in New Mexico, just north of Santa Fe. The Rio Grande and one of its tributaries flow through the valley, providing an invaluable water supply to small farmers, mainly Hispanics and Pueblo Indians. Other demands on the water supply come from predominantly Anglo developers, mining companies, and ranchers. As demands are enlarged, conflict between efficient users (the developers) and traditional water-rights holders (the Indian and Hispanic farmers) is becoming increasingly apparent.

But in addition to this rather typical efficiency/equity conflict, a jarring dispute has arisen pitting two types of "equity" values against each other. The Hispanic and Pueblo Indian populations in the valley have been sharing water there for centuries, but recent increases in water demand and more efficient water-collection techniques have resulted in overallocation of the water. The surface water and groundwater sources no longer supply enough water to fulfill all of the claims made on them by farmers, developers, and participants in the local energy boom. Thus, the Hispanics and Indians are on opposing sides of *New Mexico* v. *Aamodt*, a lawsuit in which the tribes lay claim to 36,000 acre-feet of water per year, more than four times the current average annual flow in the Rio Grande system north of Santa Fe. The fight has become bitter, with each side arguing its ancient historical rights and more recently perceived injustices.

While the Hispanics' claim to the water dates back nearly 400 years, when the first Spanish colonists arrived in what is now the United States, the Indians claim "prior and paramount" water rights for their thousand years or more of occupation. The Hispanics foresee the death of their culture if their rights to receive water are cut. They accuse the tribes of aspiring to become the state's "water sheiks." The Pueblos in turn assert that they are "just defending their rightful portion against the state and neighbors," that losing the lawsuit would represent another broken federal promise of tribal self-sufficiency, and that "the Spanish people . . . were stealing our water night and day and would not let us irrigate."

Unlike many western water disputes, this one does not directly pit a small, poor, native population against a large, wealthy newcomer. But, sadly and typically, the struggle between the Hispanics and Indians has been spurred by the seemingly irrestible encroachment of modern development upon their communal water supplies. The Hispanics' underlying concern is that the Indians will "sell out" to larger, more powerful Anglo water users such as ski resorts and industries and that the Hispanics' long-time partners in dignified adversity may become the "water bosses" to whom they must come for their water allocations. The Pueblos counter that Anglo interests would soon acquire the region's water rights in any case, that non-Indian farms thus are "probably doomed" regardless of how the lawsuit is resolved, and that Indians would be the best stewards of those water rights for future generations.

The tragedy of the situation in the Pojoaque Valley is that two long-established minorities with sophisticated cultures are being forced to battle each other while it is the well-heeled "newcomers" who are likely ultimately to benefit. If the Pueblos end up with the rights, the costs and benefits to all groups could be balanced if Anglos purchase water rights from the Indians and give (or sell at reduced prices) some back to the Hispanics. Such a solution, however, would require a degree of altruism largely unknown in the competition for water.

Government acquisition of some water rights for the Hispanics may be a somewhat more realistic prospect and one consistent with the tradition of giving federal aid to those displaced by assertions of Indian rights. The cost of such acquisition may be considerable; this suggests how high the stakes in these battles really are and in turn asks American society how highly it values cultural diversity based on historic water use.[1]

simply to keep "their" water within their boundaries could be substantially reduced. States could also regain the development potential of their water resources if and when their economies are ready to absorb it, they could reap some financial gain from the resources in the interim, and in-stream flows would be retained on the way to downstream states leasing upstream rights, thus aiding aquatic and riparian habitat, recreation, water-quality improvement, and the like.*

These are not academic concerns, considering that California withdraws about 20 percent more than its 4.4 million acre-feet-per-year allocation of Colorado River water, and upper basin Colorado River states are seeking new water projects while thousands of acre-feet lie unused in upper basin reservoirs.[115] But the desire for projects threatens to enshrine inefficiency permanently. If new storage is built, however uneconomical the uses of its water may be, that water must be withheld annually to serve those uses. If California (or any downstream state) then tries, under this interstate rights scheme, to pay Colorado (or any upstream state) to send that water downstream again, it is hard to envision Colorado accepting the money to lease its rights. Such a lease would mean letting its long-awaited water projects sit empty—even assuming they contain enough carryover storage from year to year to withhold much water in the first place. Thus, though some might claim that projects are a prerequisite for this scheme, in fact they would probably make it much more difficult to implement.

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* This technique might also be used in some cases in which the federal government is asserting a water right, whether directly or in another guise. In the recent case, *Riverside Irrigation District* v. *Andrews*,[114] the Corps of Engineers interpreted its statutory duty under Section 404 (dredge-and-fill) of the Clean Water Act as requiring it, in regulating construction of a dam, to consider the effects in another state, not only on water quality under the Clean Water Act itself, but also on water supplies in downstream wetlands under the Endangered Species Act. Effectively, the federal government is claiming a water right in Colorado (by requiring releases from the dam) for use in Nebraska (the site of the wetlands). The case is controversial not only because the releases are for out-of-state use but also because they are being done through uncompensated regulation.

But there may be other conditions under which interstate leasing could work. One would be where there are competitors lurking for the water. California might be much more interested in entering into a lease if the state thought that another state would divert the water first. Another way would be through Congress, with its power over water-project authorizations and appropriations. The congressional leverage could be applied to require leases for projects that would use more water than a state has been apportioned. In addition, political leverage could be a factor in regional alliances of governors. Such nonphysical leverage is admittedly difficult to assess, but the potential benefits of the interstate-rights concept make it well worth exploring.

Although market approaches are being considered as a way of dealing with allocating water quantities, they also are advocated for implementing water-quality programs. For instance, some economists argue strongly for the adoption of effluent fees, citing their increased efficiency. Such fees were opposed in 1972 by environmentalists (though some now support them) because they implied a right to pollute—which was considered inequitable to the public and bad for the environment. Effluent fees also are opposed by industrialists, largely, some suspect, because the fees may be more effective.[116] At mid-decade, more attention is being given to creating discharge rights, such as those being experimented with in the air-pollution-control programs, which could be bought and sold.

Conclusions

Given the intractability of many present systems of water administration, the lure of a market system is both substantial and understandable. But it can be argued that the process of apportioning uses among competing groups is essentially political and that the government can accommodate equity concerns more harmoniously and with less painful dislocation than a pure market approach can. The challenge to makers of policy in both western and eastern states in the next decades will be to identify, adopt, and harmonize the best features of both the market approach and the regulatory approach. To be effective, any solution must fully acknowledge the implications of interstate or intrastate water allocation on all the values associated with water use—efficiency, equity, and environmental quality.

WHO PAYS?

Traditionally, the answer to the question of who pays for water resources has been based far more on political clout than on economic theory or even on coherent budgetary policy. States and localities have induced the federal government to fund much water development (particularly in the West and South) and water treatment (largely in the Northeast and Midwest).[117] When the federal government has demurred, state and local governments have either paid the tabs themselves or gone without. The goal of capital spending on water has simply been to meet the ever-growing demands of every user group.[118]

But with massive federal deficits and the emergence of concerns about efficient and fair water distribution and its environmental effects, a simple preoccupation with meeting demand now seems profligate and shortsighted. The attainment of a new consensus on goals will be a long and arduous process, contrary to the political expectations of many.

At this point, in any case, federal domination in water-development and pollution-control funding is no longer commonplace. For water-resources projects, a decade or more of real reductions in federal appropriations and a congressional stalemate on funding policy have shifted the fiscal initiative to the states.[119] States also have been under financial strain due to cutbacks in federal assistance and the national economic recession and already have substantially increased taxes.[120] Thus, much of the burden of funding water supply and treatment in the future could fall on users through repayment of capital-bond obligations of local, state, or federal governments. Does this mean that federal spending on water resources will only go to users who can repay in full, or can acceptable alternative criteria for funding be found? Will states choose to subsidize certain users or ignore needs of those who cannot pay? What is the federal interest in funding any water development? Answers are needed to clarify federal spending policies and the stakes in capital water investment.

Historical Perspectives

It might seem ironic that a need for debate on the federal role in water-resources development still exists as the 20th century ends, when federal activity in the field dates from the earliest days of the republic. Yet this is not so strange when one compares the historical rationales for federal intervention in water resources with the contemporary situation. Beginning with the active emergence of the U.S. Army Corps of Engineers in 1824, the federal government, throughout the 19th century, was deeply involved in canal planning and river and harbor improvements to open up vast new expanses of the United States to settlement and commerce.[121]

During the latter half of the 19th century, federal water activities turned to making the newly settled lands more useful and productive. Flood-control programs started this trend. They were joined in 1902 by the Reclamation Act, which was intended to stimulate large-scale agricultural development in the 17 western states.[122] Subsequent programs for water power, flood control, navigation, municipal water supply, and the like were of the same ilk as their 19th-century predecessors: the central, driving theme usually was regional development, and the method of achieving it was a substantial or nearly total financial subsidy of program beneficiaries.[123]

How well did this traditional approach meet the three goals of economic efficiency, equity, and environmental quality? The efficiency of projects has been safeguarded in theory since 1936 by cost-benefit analysis, but the relative cost-effectiveness of many nominally efficient projects is still quite low, and numerous recent projects have failed to provide even the minimal levels of repayment required by law.[124] Equity was protected either not at all or on no systematic basis; the superficially equal opportunity of political deal making gave way in practice to a decided preference for projects in the South and West.[125] And, with the exception of soil conservation, environmental-quality considerations were largely ignored until the advent of impact-assessment and habitat-mitigation programs in the 1970s.

The Present: Political Stalemate

The question of who pays did not really begin to spark controversy until President Jimmy Carter unveiled his water-project "hit list" shortly after he took office in 1977. This was a group of 18 authorized projects for which Carter recommended termination of federal funding on environmental and efficiency grounds. The hit list also provided a way to begin cutting through the backlog of more than 800 approved but unfinished or unstarted projects, for which the 1978 estimated total $33.8 billion price tag had escalated to $60 billion by 1981.[126] The political reaction was immediate and violent: Carter had dared to challenge the near-sacred political consensus that then surrounded water projects. In an attempt to mollify the opposition and deal with the backlog systematically, the Carter administration proposed a cost-sharing policy, under which project construction would proceed promptly if states paid between 5 and 10 percent of the cost "up front."

This proposal did little to soothe the hostility that the hit list created. Advocates of traditional funding policy felt that times had not changed but that "we just are having a terrible problem with the President right now."[127] The traditionalists heartily welcomed the Reagan administration in 1981, believing that all this nonsense would soon be done with.

But, in large measure because of federal budget problems, it was by no means done with. The Reagan administration's policy makers instead sought to up the states' required ante to 35 percent. In response, Senator Paul Laxalt (R.-Nev.), a close presidential ally, and 14 other western Republican senators wrote President Reagan that his cost-sharing proposals were "even more Draconian" than President Carter's and that they would "be painted as 'anti-water' " and threaten the president's western political base.[128] But the new reality in water was slowly dawning, for five other western GOP colleagues—including the chairman of a key Senate water subcommittee, Senator James Abdnor (R.-S.D.)—failed to sign the letter.

Although President Reagan in January 1984 appeared to bow to this partisan pressure by agreeing to treat project cost-sharing on a case-by-case basis and to abandon cost-sharing for dam-safety repairs, it was unclear whether this retreat would actually spur more project authorizations or new construction starts—particularly in the face of $200 billion budget deficits—or, more important, whether the new case-by-case policy would be abandoned after President Reagan's 1984 reelection campaign.[129]

As debates on the advisability of continuing traditional water-development policies rage on, there is little dispute about the political reasons behind the present stalemate: the long-standing national consensus in favor of subsidizing regional development by water spending has disappeared. This disappearance is observed even by a Washington, D.C., representative of traditional user groups, who concludes that, "For 200 years we've been running out and putting a Band-Aid on water problems.... We need to study and reflect, and determine what kind of a program we should have."[130] As a result, no major new water projects have been authorized or begun since 1976, and overall appropriations for water-project construction (excluding municipal wastewater-treatment plants) have plummeted by nearly 70 percent in the eight years since (figure 7.4).[131]

Certainly, the mounting federal budget deficits of the last 10 (and particularly the last 3) years, together with three major national recessions during that period, have played an important part in changing policy. These fiscal constraints, in turn, have highlighted the inconsistencies and inequities in present cost-sharing policies. The proportion of federal project costs that are recovered varies widely, depending on project purposes and agencies, from a federal government average of 6 percent for inland waterways to 64 percent for hydroelectric power and municipal and industrial supply (figure 7.5).[132] The disparities reflect the patchwork nature of present federal water programs, and the resulting inequities make the old policy consensus that much harder to defend. As one environmental lobbyist notes, "Pressures of the budget are going to force a rational evaluation of water project authorizations, and rational evaluation is the antithesis of pork barrel."[133]

An additional, key factor in the demise of the old consensus, however, has been the political objections of northeastern and midwestern congressional blocs to the heavy, almost exclusive weighting of water subsidies to favor the already booming southern and western regions of the country. The older regions have discovered their own need—the repair of crumbling "infrastructure" such as sewage and water-supply systems—which threatens to overwhelm state and local budgets in areas of economic decline. Representatives from these regions see little reason to pay for water infrastructure that would lure still more jobs to the Sunbelt and accelerate the industrial depression of the North.[134]

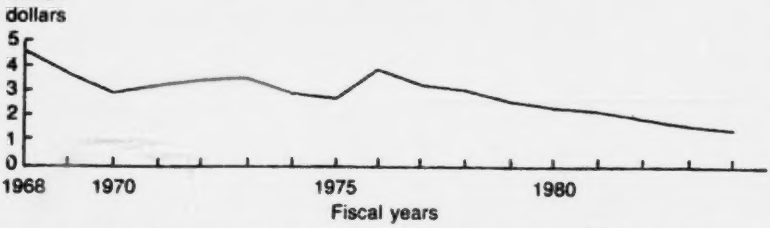
The Basic Issues

Some observers discern in the decline of new capital investment a loss of national will. They appear to embrace a sort of social catastrophism and to yearn nostalgically for the "good old days,"[135] not unlike some environmentalists' longings for a time of mythical, primitive harmony with natural systems. There is little reason to endorse such a superficial view; indeed, the present "infrastructure crisis" should teach the shortsightedness of always equating politically attractive spending on new construction with wise investment policy.[136]

Predictably, the current political debate is more narrowly focused. The question of how much the federal government should give to whom predominates, with all sections of the country attempting to justify their

Figure 7.4

Federal Appropriations for Construction of Water-Resources Projects, 1968–1984 (in constant 1982 dollars)

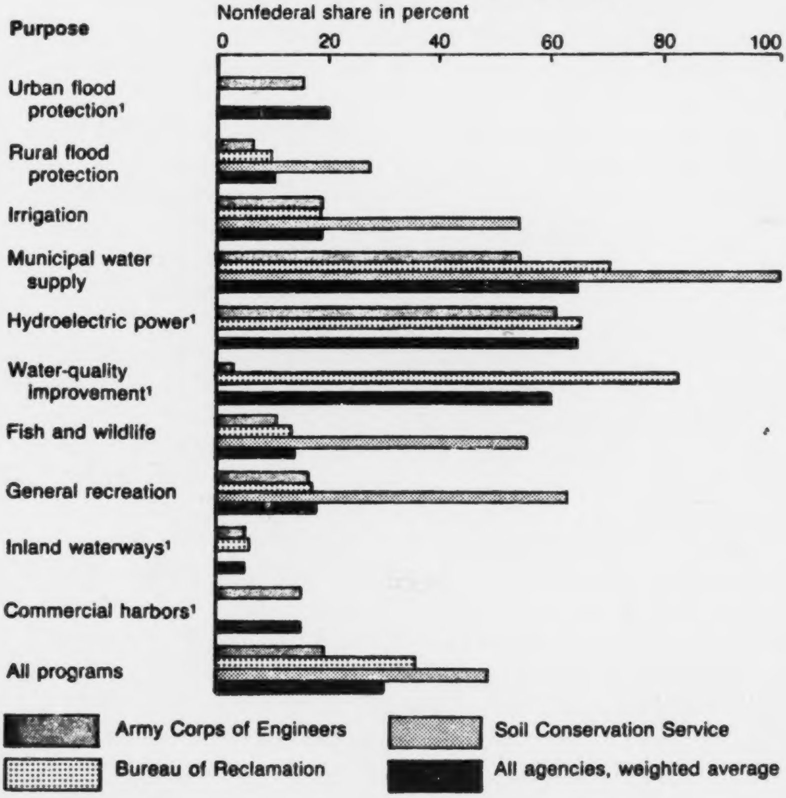


Figures do not include Colorado River Basin Trust Fund expenditures. Fiscal year 1984 figure is from president's budget; actual appropriation will not be known until end of fiscal year.

Source: Congressional Budget Office.

Figure 7.5

Effective Nonfederal Cost Shares of Federal Water-Resources Development, by Purpose and Agency



[1] Either activity or cost share not reported by some agencies. See figure references.

Source: Congressional Budget Office.

claims on such grounds as past promises, regional equity, political power, or comparative poverty. The emphasis has been on working out compromises that will get the dollars rolling again, but no proposal seems able to win general acceptance. And, in the process, several basic questions are, for the most part, being ignored. In view of the disappearance of the old funding consensus, no proposal will gain lasting approval until certain questions get direct answers.

Why More Capital Investment?

One of these questions is whether more development really makes any sense. Most of the best dam sites are already used up. Those remaining typically would be much more expensive to develop—as indicated by the rapid increase in the average amount of material that has to be placed in the embankments to create an acre-foot of reservoir capacity (figure 7.6). As a result, most experts concur that few undeveloped sites remain that are both environmentally acceptable and economically efficient.[137] The full exploitation of water resources in many major river systems suggests that the land-settlement and water-resource phases of the nation's development are virtually complete.

The emphasis on building more projects seems even more questionable given the budgetary dimensions of the more than $60 billion project backlog and the current problems in operating and maintaining the investments already made. As one expert observes, there should be a "rethinking [of] our sense of what capital investment is 'needed,' and overhaul[ing of] the institutions ... that have led to under-maintenance and postponed repairs."[138]

The problem of inadequate operation and maintenance is probably nowhere better demonstrated than with municipal waste-treatment plants. Congress has appropriated about $38 billion in federal funds alone to construct such facilities over the past decade, but the General Accounting Office estimates that as many as 82 percent of them are not being operated properly.[139] Similar fears were raised with respect to the maintenance of dams when the Teton Dam failed in June 1976. The U.S. Army Corps of Engineers estimated in a subsequent survey that one-third of the dams it inspected were unsafe, and a tenth of those required emergency measures to prevent "imminent failure."[140]

The emphasis on capital construction also may prevent dealing with water shortages by other techniques that are more cost-effective. In many cases, existing conflicts may be resolved and substantial amounts of money saved by managing existing supplies more efficiently rather than by developing new ones.

Work done in the Washington, D.C., metropolitan area over the past five years is a dramatic example of these techniques. For decades, there were often bitter disputes about how many dams would have to be built to guarantee adequate water to the area, which has periodically had to declare emergencies because of shortages. No consensus could be reached, however, and sharp population growth caused the shortages to get worse. Finally, some of the major water institutions in the region decided to explore options for better management of existing supplies. The results were striking. After undertaking a combination of measures—improved hydrologic assessments, a conservation-oriented rate structure and education program, more efficient institutional arrangements for operating and connecting different parts of the existing water-delivery system, the reallocation of some storage in Bloomington Dam from flood control to water supply, and the construction of one small reservoir—the parties were able to conclude that existing supplies would be adequate for another 50 years without building the $250 million or more worth of reservoirs that had been recommended (figure 7.7).[141]

One of the leaders of this effort attempted to estimate the implications of adopting similar management improvements more generally. He concluded that it should be relatively easy to achieve a 10 percent to 15 percent improvement in the operating efficiency of federal projects and that such an improvement would be "worth just as much" as 20 years of new construction. The costs of achieving such an improvement would be very modest—probably less than 1 percent of the amount currently spent on new construction—to produce the same benefits.[142]

Similarly, in many instances in which new construction in general and interbasin diversions in particular are demanded, the least-cost means of obtaining the desired amount of water is, instead, to repair old or inefficient water-delivery systems or to subsidize installation of water-saving devices in homes. (Orlando, Florida, has spent over $400,000 for home water-saving devices as a "supply" source.) The demand by various regions of the country for more federal project dollars may snuff out opportunities for cost-effective nonstructural or lower-cost structural investment. Before charging ahead with massive capital-spending programs, it seems wise to ask whether they are necessary.

What Should Users Pay for Water?

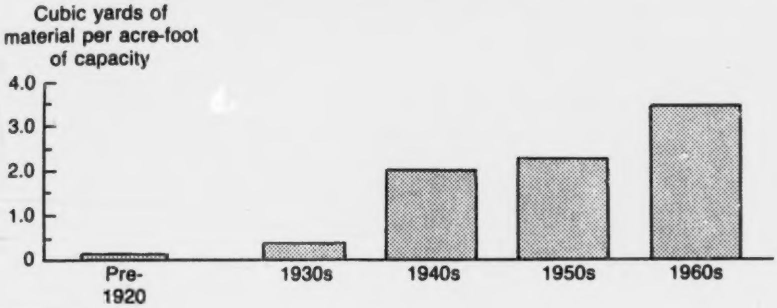
A second basic question is how further capital investment in water under the present water-pricing policies can be afforded. Only rarely in the United States does any government treat water as if it were a valuable commodity. In almost every state, unclaimed water is given to anyone who asks for it; the only charge, if any, for making a transfer formal is a permit fee that usually does not even cover the cost of the paperwork. More than 55 percent[143] of water-supply utilities charge by declining block rates, which discount water to large users, especially commercial and industrial classes. Such favorable rates encourage inefficient use, requiring a search for more expensive new supplies and inflating a utility's total costs. In addition, many public companies do not even recover their full costs—they receive tax, interest rate, and sometimes (in the West and South) indirect federal subsidies.[144] Thus, much water is sold for less than it costs to obtain it.

Even when revenues do cover costs, a user may not actually be charged for the amount of water used. If water use is not metered, a household that never waters its lawn may be charged as much as a household that leaves its sprinklers on continuously. Many communities—for instance, New York City (23 percent metered) and Chicago (31 percent metered)[145]—do not have universal metering of individual residences. The many old apartments in those cities require replumbing to meter all residences, and this exacerbates the problem. Still, the demonstrably substantial savings from metering and from rates based on the amount of water consumed point to a need to require metering in future construction, particularly when old apartments are rehabilitated.

Most federal programs are operated on the same basis. On a national average, irrigation water is priced at 19 percent of the real cost of supplying it, and in some cases there is no limitation on the amount of water that may be consumed.[146] However, there often is a limit on the amount of land that farmers may irrigate with that water. Limiting the amount of land irrigated but not the amount of water used clearly eliminates any incentive to stretch supplies through conservation.

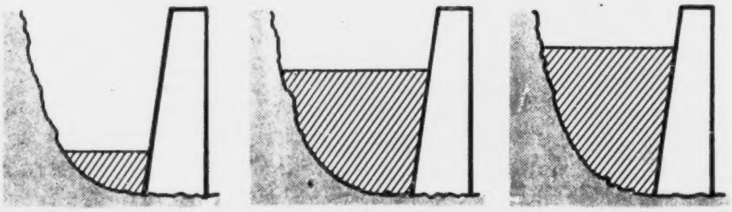
Such pricing policies have long been justified by reference to equity principles in various guises. In irrigation, the original idea that reclamation benefits are "national in character" could apply to virtually any economic sector. But at a time when western farming is neither new nor disadvantaged, the system is distinctly inequitable for those farmers (particularly in the West) who lack a water subsidy. The subsidies might or might not be endorsed if Congress addressed the issue directly as

Figure 7.6
Volume of Dam Material Required Per Acre-Foot of Reservoir Capacity, pre-1920 through 1960s



Source: Langbein.

Figure 7.7
Water Remaining in Washington, D.C., Metropolitan Area Water-Supply Reservoirs after Severe Drought



Case A Case B Case C

Case A: Without improved management (13.5 billion gallons remaining).

Case B: With improved management. "Improved management" here includes regional cooperation among state and local governments (40.2 billion gallons remaining).

Case C: With improved management and 50 percent of flood control reallocated to supply. Reallocation of 50 percent of flood control to supply storage reduced flood-control benefits by approximately 7 percent (46.1 billion gallons remaining).

Total reservoir capacity is 60.3 billion gallons.

Source: U.S. Army Corps of Engineers.

an element of national farm policy. But at least they are no longer needed to achieve the initial aim of aiding settlement of the West.[147]

Pricing municipal water below real cost, it is sometimes argued, is worthwhile because water is necessary for survival and thus must be available to all in adequate quantities. But under most utilities' water rates, those who use only minimal, "survival" quantities end up subsidizing larger users.

It is not surprising that, even while water is subsidized, much agonizing about how to cope with increasing water shortages and how to pay for new development goes on. A recent study emphasizes that the ability of localities to pay for new water is closely tied to the way they charge for the old; the more they give their water away, the more difficulty they will have in financing new development.[148] This is even more the case with wastewater treatment, for which most utilities have failed to adjust rates adequately to compensate for the recent decline in federal subsidies. One expert observed in 1983 that "heavy reliance on relatively unpredictable subsidies (most prevalent for wastewater systems) exposes the utility to future managerial and financial crises."[149]

In some areas, citizens and their governments may be coming to understand the importance for future economic stability of limiting water depletions. Orange County, California, fashioned a strong local response to the nationwide problem of excessive groundwater pumping by charging water users a $24 tax for every acre-foot of water they consumed (in addition to the well owner's pumping costs).[150] Arizona's Groundwater Management Act permits the state to impose such a charge, although the purpose is to provide funds to operate the management program rather than to reflect the true value of the water. Nevertheless, as breaks with the tradition that water should be given away, both measures should reduce local demand for new water and better enable their jurisdictions to afford supply measures if and when they become necessary.

Why Should the Federal Government Pay?

The third basic question has three parts: Should the federal government help pay for water developments at all? If so, for what purposes? And how much? The "how much?" question is the focus of most of the current debate in Washington, D.C., but it is being treated as the only question, not the last.

Political back-scratching may have worked well enough in a period of established policy consensus and flexible budgets, but it no longer does. The old method of authorizing a discrete and easily comprehensible list of specific projects to fund is defunct. A clear new policy rationale for federal involvement in water funding might win broad political support, but none has yet been developed. In the absence of a clear rationale with local support, any "new" approach that is fundamentally a political-logrolling appropriations scheme (for example, unconditional block grants or loans) is liable to find its support evaporating during any budget squeeze. Some politicians have noted this, arguing that placing the cost-sharing cart before the program-rationale horse is, "to put it mildly, an exercise in futility ... when ... the probability of federal participation now and in the foreseeable future will be nil."[151] This is not, then, a fight over who gets funding—whatever grant or loan formula is chosen decides that—but over whether any budgetary support at all should be expected for a program that lacks clear goals.

So can a supportable goal or underlying rationale be found? One state-level group defined "national interest" in water development as including projects that "address national defense, international and interstate commerce, major energy development, and multi-state or regional problems."[152] An examination of this list illustrates the difficulty of defining national interest, now that regional development is no longer a consensus objective and now that purely local benefits from such development are not seen as automatically enhancing the national interest. Defense certainly is a national goal, and energy development arguably is; but projects to provide water for these purposes are almost inevitably formulated to concurrently provide substantial, strictly local benefits.[153] Some projects may be built solely to meet international treaty obligations (such as the desalting plant in Yuma, Arizona), but they may indirectly subsidize local water users. These projects thus produce local as well as cross-boundary benefits. Other examples are the Great Lakes municipal treatment plants that aid local fishing and water supply while fulfilling U.S.-Canadian agreements.

Interstate or regional problems comprise perhaps the most troublesome category of national-interest goals. Some parties cite, as support for a continuing federal role, the difficulty and duplication involved in organizing several states for a single project.[154] Perhaps, the federal government could buy state cooperation with financial assistance, but this technique would look very much like the subsidies of sectional growth that have lost favor. A never-quite-defunct proposal for a federally funded North American Water and Power Alliance project is a classic example of the sectional dynamic carried to its extreme. The $50 billion to $200 billion fantasy project—to bring water from the Canadian Yukon to the American Southwest by means of transcontinental canals and a 400-mile-long trench reservoir at the U.S.-Canadian border—is clearly an interstate project that, equally clearly, would shovel unprecedented subsidies into the Colorado River basin.[155]

Instead of looking at types of projects that the federal government might help fund, one can look at different types of benefits that projects can produce. This has been the traditional approach, and it accounts, in part, for the wide disparity that has existed in federal cost-sharing policies among programs and agencies (demonstrated in figure 7.5). Perhaps, for instance, the federal government should pay part of the cost of providing benefits if most beneficiaries could not easily be identified and charged. This might apply to water resources devoted to federal lands or to wildlife habitat, particularly that used by migrating wildlife. It certainly would be the case for water used for national defense purposes. It would not, however, apply to water for municipal or irrigation use. This is the view argued by the National Water Commission, which concluded that subsidization should be offered only where "conventional markets and pricing mechanisms cannot be counted on to achieve socially desired benefits." The commission, however, left open the question of what such socially desired benefits might be.[156]

Water pollution control provides probably the most obvious example. Because the pollution usually damages someone other than the polluter—creating a market externality—the federal government stepped in to require cleanup. But just because government has a role does not demonstrate that government should pay the costs. And, in fact, the two major types of point sources are treated differently: industrial polluters must pay essentially all the costs of their pollution-control practices, while the federal government provides a large share of the pollution-control costs of municipalities. Most municipal-sewage charges are now so low that even substantial increases would be unlikely to raise serious ability-to-pay questions.[157] However, reducing or cutting off federal construction grants would force many municipalities to choose between a sudden, drastic sewer-rate hike and continued violation of EPA effluent standards (which must be met regardless of the availability of federal funds).[158] The continuation of grants (even at the 55 percent level that goes into effect in 1984, down from 75 percent) could offer an opportunity to promote more flexible, innovative ways of meeting quality standards if EPA were to create incentives to substitute nonstructural, least-cost approaches (such as nonpoint-source pollution control) for traditional, capital-intensive, secondary treatment plants.[159]

A third approach to federal involvement is to use federal funds to remedy disparities in the ability of different states or localities to finance their own needs. This approach handles the difficulty that state and local governments are having in maintaining basic public facilities, including water-supply and -treatment facilities, as a problem that has risen to nationwide significance.[160] Representatives of the Northeast and Midwest cite the fairness issue to support making federal assistance for repairing municipal facilities on which people's homes and livelihoods already depend a higher priority than assistance that promotes new growth.[161]

But any new proposal must define eligibility narrowly, or it will become essentially the same "subsidize everyone" type of water program. As a nation, the United States no longer can afford an approach that prefers buying off potential opponents to assure that funds are delivered to the deserving—rather than defining needs at the outset. If the country chooses to underwrite needy areas, Congress should fully define "local need" itself and not leave this to the discretion of Executive Branch agencies. With the recent history of federal-state conflict in water policy, the outlook is poor for any new water program that requires federal bureaucrats to tell states what their needs are.

Principles for Decision Making

After Congress answers some of the basic questions posed in this chapter and defines the goals for federal water investment, it will then be appropriate to consider the options for putting those goals into action. This section will not discuss specific proposals for grant formulas, state percentages, user-fee schemes, or the like; for those, the reader is directed to the recent profusion of more technical discussions.[162] Instead, some principles to guide specific implementation proposals are suggested.

The first principle is that funding from any source should support only the least-cost solution to a water problem—without regard to whether that solution includes a politically advantageous and visible structural proposal. Water funding is now authorized to build specific kinds of projects—dams or treatment plants—not to solve water problems as such. Of course, solutions may continue to include big structures, but a very poor return on society's water investments will persist so long as nonstructural and system-management improvements are not supported on the same basis as physical structures.

The second principle is that, as a general rule, all types of users should pay the full cost of getting water to them. It is a matter of common sense that users will not be able to pay for new or rebuilt water facilities unless they are charged for their present use on the basis of what replacement water, in the form of such facilities, would cost—that is, the marginal cost of new water.

The third principle is that any federal subsidy for water should recognize the first principle of least-cost problem solutions and should be explicit about its rationale for violating the second, user-pay principle. Where the federal government is itself the user—for instance, when water is required for national defense or for protecting endangered species—the user-pay principle is in fact observed. And where subsidies of state and local governments or private users are employed, the targeting of the subsidies must be narrow to ensure that they are given only to those for whom Congress expressly affirms a specific need. In other words, the historical subsidies in this area (whether or not justified in the past) promise to impose such a high cost on society if continued that further government intervention on equity grounds should be restricted to the neediest cases.

CONCLUSIONS: CROSSING THE WATERSHED

U.S. water policy has entered a period of fundamental change. This change may be deceptive because it is gradual, sometimes imperceptible, and often at variance with public rhetoric. But cumulatively it adds up to a distinct departure from past practices and mindsets. In the words of many policy experts, the nation is moving from an era of water development to an era of water management.

Several examples cited in this chapter mark that trend. Instead of developing new water supplies and facilities to meet new demands, existing supplies and facilities are being reallocated to different uses: the shift of Maryland's Bloomington Dam from flood control to water supply for the Washington, D.C., area, and the buy-outs of western agricultural water by urban, industrial, and energy users.

Another aspect of the trend to water management is the physical modification of water facilities to accommodate broader, newly recognized values. Florida provides a particularly dramatic example, perhaps because its natural systems were so extensively modified by earlier projects. The U.S. Army Corps of Engineers is actively involved there in attempting—by such means as shifting the Kissimmee River out of its government-constructed, artificial channel back into segments of the natural river and adjacent river floodplains—to re-create marshes, belatedly recognizing the importance of environmental values ignored by the narrow emphasis of the earlier development on economics alone.

A third manifestation of the transition to a management era is possibly the most central one: simply making existing uses work better. The Colorado River's salinity issue exemplifies this trend. In the proposed salinity-control measures, agricultural water use would be maintained in full but would be made more efficient by installing water-conservation measures on farms and in irrigation-district facilities. In the Salt River Project in Arizona, a vigorous use-monitoring program has reduced losses of water unaccounted for from nearly 30 percent in 1971 to less than 19 percent by 1981, with projected further reductions of up to 10 percent within a few years.[163] Similar results were obtained by the state of Idaho on one stretch of the Snake River.

Though these changes are quite diverse, they do seem to share one important characteristic. They are specific responses to local problems, not coordinated answers developed out of any overriding national theory. Ironically, as noted earlier, these changes often have occurred at the same time that an area was publicly calling for a return to subsidies or other policies of the development era. Arizona adopted a radical groundwater-conservation law and Tucson drastically hiked the prices charged for water while they were publicly fighting federal cost-sharing proposals that demanded higher state contributions. Boston organized its fragmented water utilities into an areawide entity, increasing water delivery efficiency and financing capability, while the East was asking for federal funds to repair its deteriorating road and public-utility systems. State and local governments are embracing innovative, forward-looking management far more widely and quickly than their public rhetoric might suggest.

This does not imply that no federal role in any of these areas is needed or warranted. Rather, it suggests that regional demands for the restoration of traditional water-development and water-treatment subsidies should be discounted somewhat and, more important, that any federal action should be tailored to recognize, complement, and reinforce the nascent efforts toward improved water management. Thus, a federal role in research, information transfer, and technical aid is clearly indicated. If any federal financial assistance is given, it should be targeted to areas where earnest and innovative efforts nonetheless leave a core of need that is clearly beyond state or local capability to address unaided. The federal government should not respond unthinkingly to plaints of incapacity or to vague promises of national benefits.

In fact, forced by diminishing federal water budgets, state and local governments are beginning to turn, of necessity, to the least-cost alternatives that national water-policy experts long urged to no avail. Similarly, the user-pay philosophy is winning adherents not by force of rationality but by unavoidable budgetary and practical necessity. Change is stemming simply from adaptation to new conditions. The United States no longer has the unending water surpluses, overflowing capital budgets, or clear policy consensus to continue as before. With new participants, limited funds, and overcommitted water resources becoming common across the country, individual areas are crafting answers responsive to local conditions.

This search for least-cost, user-supported actions that integrate quality and quantity, and sometimes transcend jurisdictional boundaries, cannot be mandated from Washington, D.C. But it can be either stimulated or discouraged by federal programs, and either nurtured or ignored at the state and local level. The challenge today for policy makers at all levels is to recognize the validity of, and learn about the potential of, the shift to water management, and to understand how management often can harmonize efficient and equitable use of water with environmental quality. Policy makers then will be able to see how best to apply these broader lessons to the water problems faced by each area of the United States.

FURTHER READING

Although it was completed over a decade ago and is now out of print, the 1973 report of the National Water Commission, *Water Policies for the Future,* continues to set much of the agenda for policy reform today. Its analyses are both comprehensive and detailed, and the many background papers prepared for the commission (if of uneven quality) are often important studies in their own right.

A classic, incisive statement on water-resource issues, which also remains appropos, is the short report issued by the National Academy of Sciences in 1966 entitled *Alternatives in Water Management* (Washington, D.C.: National Academy of Sciences, 1966). A different, stimulating, and sometimes controversial libertarian free-market perspective is offered by Terry Anderson's *Water Crisis: Ending the Policy Drought* (Washington, D.C.: Cato Institute, 1983).

On more specific issues, the Congressional Budget Office's report, *Efficient Investments in Water Resources: Issues and Options*

(Washington, D.C.: U.S. Government Printing Office, 1983) is a concise and thorough exploration of the cost-sharing issue, one that can be used both as an introduction to the issue and as a definitive analysis of its economic aspects. The recent series, *Water In the West* by Western Network (214 McKenzie St., Santa Fe, N. Mex. 87501), has useful, detailed, and generally objective summaries of many specific cases in the two titles available to date, "What Indian Water Means to the West" (1983) and "Water for the Energy Market" (1984). A third volume on urban water conflicts is forthcoming. A technical but very readable discussion of another, increasingly visible national issue is provided in *Groundwater Contamination in the United States* by Veronica I. Pye, Ruth Patrick, and John Quarles (Philadelphia: University of Pennsylvania Press, 1983).

Up-to-date sources on regional issues, though fairly common in the past, now seem more difficult to find. As might be expected, western-oriented sources predominate. Perhaps the best known is the absorbing story of the Colorado River, Philip Fradkin's well-written and thorough *A River No More: The Colorado River and the West* (New York: Knopf, 1981). Water issues are covered for all the Rocky Mountain states by the biweekly *High Country News* (224 Grand Avenue, Paonia, Colo. 81428). While its articles often have a clear environmentalist slant, they generally strive to bring out facts on all sides of an issue and provide much information not otherwise available. William Ashworth's volume, *Nor Any Drop to Drink* (New York: Simon and Schuster, 1982) offers a useful and readable variety of stories about water supply and quality problems across the country, though it is written in a dramatic, occasionally apocalyptic tone. The weekly *National Journal* (1730 M Street, NW, Washington, D.C. 20036) often gives its characteristic, objective, scholarly treatment to regional water issues, but it is more often a vital source of news and interpretation on national and congressional water politics.

Finally, the U.S. Geological Survey has undertaken the preparation of annual assessments of water issues, including both water quality and water quantity. The first volume, *National Water Summary 1983—Hydrological Events and Issues*, USGS Water Supply paper 2250 (Washington, D.C.: U.S. Government Printing Office, 1984) is a well-illustrated, informative document containing succinct statements of issues in each of the states as well as a national overview.

CHAPTER 7: WATER RESOURCES

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WATER IN AMERICA 1983

A Report by the Office of Water Policy, Department of the Interior
To Acompany the U.S. Geological Survey's
National Water Summary 1983

Providing enough high quality water promptly to those who need it is a task that has confronted Americans since the earliest days of our national experience. In the very first summer at Plymouth, America's first permanent English settlement, the Pilgrims saw their crops wither in the face of a summer drought. Fortunately, the drought ended before their first winter's food supply was ruined. Three-and-one half centuries later, in 1983, there were record spring floods in the lower Colorado River Basin and the lower Mississippi and record droughts in the the East and the Midwest. The key lesson we can draw from these experiences is that providing high quality water to those who need it when they need it is a never ending process.

The Federal government's involvement in water decisionmaking has grown over the past several decades, as has been the case in many other policy areas. Much of the government's involvement has undermined traditional State authority over the allocation and management of water. This displacement of State prerogatives by an expansionist Federal government is one of the trends President Reagan has vowed to reverse. Having served as Governor of a semiarid Western State, he understands the importance of protecting and strengthening the primacy of State governments in allocating and managing water resources. The President is also deeply committed to opening Federal doors to new partnerships with the States, communities, and private citizens and examining regulatory requirements with a commitment to simplify and streamline the process.

We have made major strides in implementing programs reflecting the President's views. We have put in place new "Principles and Guidelines" for water project planning which remove cumbersome and burdensome regulations, promote flexibility in planning, and encourage water project development. We also have proposed ten new water project starts and moved aggressively to complete those already under construction. Central to seeking new partners has been the Administration's support of cost-sharing plans. After consultation with Governors and other interested groups, we developed a policy for financing new water projects in cooperation with non-Federal sponsors. Cost-sharing arrangements will be established on a case-by-case basis according to the sponsors' ability to participate, taking prior commitments made by the United States into account. We have also taken steps to end uncertainty about water supplies in the West by offering to negotiate both Indian water claims and Federal reserved water claims with the States. Finally, just last year, we worked with Congress to modernize the 1902 Reclamation Act's acreage limitations.

A year ago, Secretary James G. Watt asked the U.S. Geological Survey and the Office of Water Policy to develop and implement a system that would accurately characterize the condition of our Nation's water resources and the efficacy of the Federal establishment's efforts to assist States, localities and private entities in meeting America's water needs. Policymakers in both the private and public sectors require timely and reliable information to anticipate and prepare for the hard decisions that must be made in meeting these needs. The two publications available today are the first products of this new system. The Geological Survey's *National Water Summary 1983* presents in useable form an accurate appraisal of water availability and quality and the hazards associated with it. *Water In America 1983* looks at some of the public policy issues raised in its companion report. These two publications both clarify and highlight the decisions that must be made to assure full development of water resources and environmental protection.

Garrey E. Carruthers
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Department of the Interior
November 1983

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EXECUTIVE SUMMARY

The *National Water Summary 1983* provides a detailed look at water resources conditions throughout the United States. Several policy issues emerge from this review of regional and State data relating to the availability and quality of our water supply and the impact of natural hazards such as drought and flooding. Of these, six policy issues have been chosen for special attention in *Water in America 1983*. Their analysis explores the kinds of problems posed by underlying hydrologic conditions, the changing roles of Federal, State and local authorities, and promising trends in solutions developing at each level of government.

Improving River Management. Better management tools are now being applied to such problems as the operation of reservoirs and water delivery systems. Use of simulation modeling in California and on the Tennessee and Potomac Rivers to make and carry out decisions offer examples of successful high technology application. Conventional wisdom impedes the change toward cooperative, integrated decisionmaking in river management that is necessary before high technology can be used to greater effect.

The physical interconnectedness of heavily engineered river systems offers many options to the solution of water resource problems. Intense competition for water can provide solutions through cooperative and innovative management. Computer technologies can help to identify available options that are within legal and other management requirements.

Interstate Water Conflicts. Recent Court decisions have challenged State primacy in water management. A decision in *Sporhase v. Nebraska* by the U.S. Supreme Court determined that, since water is an article of interstate commerce, there are limits on the ability of State governments to restrict the export of water beyond State boundaries. In a similar case, *El Paso v. Reynolds*, a lower Federal Court held that New Mexico's ban on water exports to the city of El Paso, Texas, was discriminatory because it treated in-State and out-of-State water users differently. Continued litigation is anticipated over restrictions on interstate uses.

In another development, South Dakota's willingness to sell water to a pipeline company for coal slurry shipments was challenged in court by three States located downstream on the Missouri River, the source of the water. Use of traditional interstate compacts is suggested as a solution to this and other interstate conflicts, but there may be legal impediments to their use.

Water Project Development. Water resources development is still needed for an expanding economy, but project backlogs, rehabilitation needs and budget deficits suggest the urgent need for new mechanisms for the funding of economically and environmentally sound water development. This Administration has taken several steps to resolve policy barriers including new planning procedures, reform of Reclamation Act acreage limitations and cooperative, adjustable cost-sharing arrangements. Both Western and Eastern States are responding to the need for water development through innovative financing arrangements.

Indian Water Claims. As long as Indian water claims remain unresolved, water users are uncertain about the validity of their water rights, water managers cannot establish how much water is available for further appropriation, and Indian tribes are without the means to develop reservation resources. At the State and Federal level, increasing reliance on negotiation, rather than litigation, offers the potential for more timely and cost-effective settlements, to the benefit of all parties. The Reagan Administration strongly supports negotiated settlements for resolving Indian water claims. Some States are looking to negotiation as an alternative to costly and time-consuming stream adjudications.

Water Quality: Acid Rain and Salinity. The Department of the Interior has responsibilities, through the Geological Survey and other bureaus, for conducting studies of the quality of surface and ground water. While the Environmental Protection Agency has primary responsibility for enforcing clean water legislation, the Department carries out water quality control measures on public lands.

Acid rain is a contributing factor in surface water acidification, with possible harmful impact in many States. The Administration is accelerating research to advance the decisionmaking process.

Twelve State summaries in the Survey's *National Water Summary 1983* mentioned that surface water quality is adversely affected by salinity. Along the coastal areas of the United States, many municipal water supply systems are also experiencing salt-water intrusion into ground water. Federal policy on increasing salinity presently emphasizes research. Responsibility for solutions falls on municipalities and local jurisdictions except for specific cases of national or international interest. With the prospect of increasing rather than decreasing impacts on water quality from this source, local and regional strategy models are being developed.

Introduction: Major Policy Issues

The United States has an abundant water supply on a nationwide basis. Periodically, events such as floods, droughts, and incidents of water contamination occur in various regions and locales. Augmenting water supplies for rapidly developing areas creates policy issues for mayors, county commissioners, State legislators and other elected officials as well as for leaders in agriculture, business and education. There also is widespread concern about ground water, especially ground-water contamination and over-pumping. In the face of news about threats to (and threats from) their water supply, Americans want to know how it can be better managed to support a robust economy and a protected environment. *Water In America 1983* provides a special look at six of the most urgent water issues facing us today.

Improved management of water resources requires periodic review of the changing nature of policy decisions. The Geological Survey's *National Water Summary*'s State-by-State review of water issues provides examples of effective and innovative solutions. The States, with their primary responsibility for water allocation, are dealing with a large number of complex water issues. They are finding ways to fund water development projects, negotiate water rights issues, plan for the wise management of water resources and encourage cooperation among competing users.

The changing nature of Federal/State roles is widely apparent in the *Water in America 1983* analysis. A Federal role is widely ackowledged for coordinated data-gathering and research, for action against the disasters of flood and drought, and for technical assistance with interstate and regional problems. The need for State initiative and State assertion of primacy is clear. The ideal result of the changing policy style is a partnership that responds well to management challenges.

Improved management of water resources also requires extensive knowledge about water use, present and anticipated shortages, advanced technology and methods of resolving conflicts. The Survey's *National Water Summary 1983* presents an account of the physical conditions of our water resources. The issues chosen for the present review were selected from those raised in that *Summary*.

This 1983 edition of *Water in America* analyzes some of the more significant policy issues that emerge from the *National Water Summary*. For each major issue, the nature and the background of the policy at stake are summarized. Important questions are asked: What kinds of problems do the hydrologic issues pose for public leaders and private citizens? What has been the issue trend over recent years, and what has been done to bring about solutions? What promising directions are available at the local, State and Federal level?

This Administration continues to seek and form new State/Federal partnerships. The Office of Water Policy (OWP) established contact with policymakers at the State and local level. Future issues of the *National Water Summary* and *Water In America* will reflect suggestions from their users and will result in revisions of format and substance. Comments are invited at any time and should be sent to:

Director, Office of Policy Analysis
Department of the Interior
Washington, D.C. 20240

Improving River Management

The Issue: **We are only beginning to realize the full potential of effective river management, but currently available high technology as a tool to facilitate decisionmaking should be used to help reduce conflicts over limited water resources in heavily developed river basins.**

The Problem

Severe river management problems will no doubt continue. Earlier this year, for example, highly unusual weather patterns accelerated interest in seeking new ways to improve the management of river systems. Record levels of precipitation sent the Colorado River to almost three times its normal level during the late spring and early summer of 1983, causing extensive flood damage. At the same time, severe drought combined with high temperatures seriously affected crops in the Corn Belt as well as elsewhere in the country.

While Mother Nature is fickle, river managers frequently are not. It is all too easy to fall into a pattern of management that changes little year after year, even though user needs and weather patterns may change drastically. Indeed, with the complexity of river management, consistency may seem to be the safest course — a way to avoid harming someone's legal right to water use.

Rapid advances in recent years clearly show that river management technology can be helpful in meeting the challenge posed by nature and by competing uses. In most river basins, operational policies require that a balance be struck among competing users. With the advent of the modern computer, joint decisionmaking on the part of competing interests could take on a new and exciting meaning.

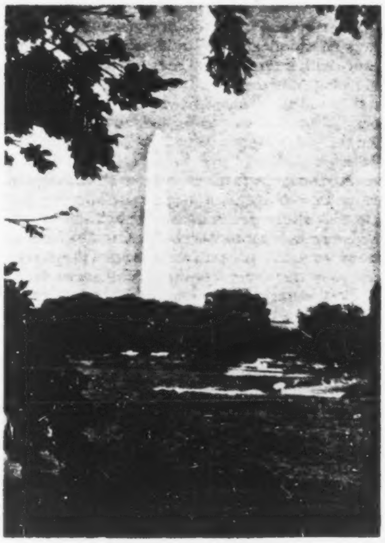
High project costs and lack of funds forces more efficient use of dimishing water resources. This trend requires the extensive use of computers to estimate the water needs of all users, to measure facility needs and to identify alternative schemes for achieving selected management objectives (such as increasing yield) or solving certain specific management problems (such as minimizing the impact of drought). This promises a way to break out of old patterns, increase system yield and at the same time protect all existing users.

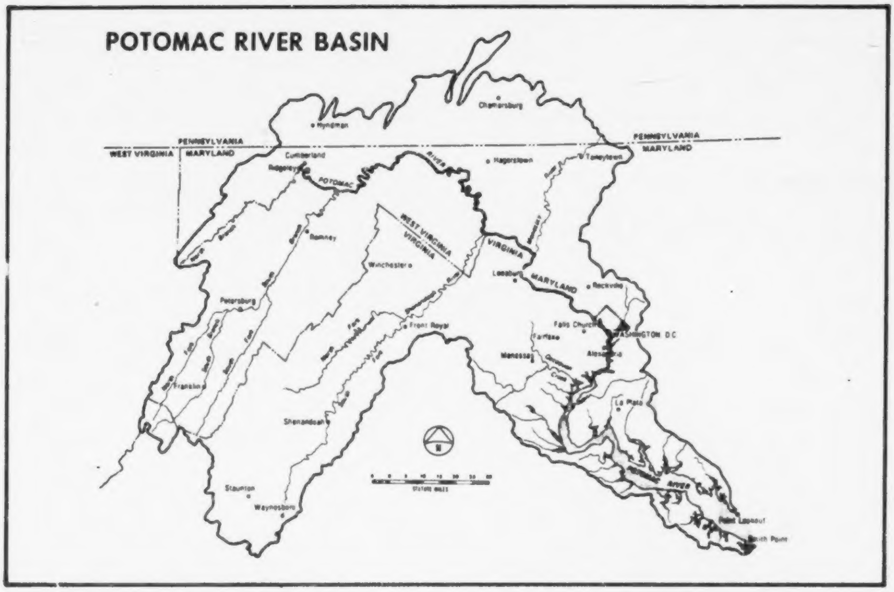
A Potomac River Solution

In 1982, decisionmakers responsible for water supply in the Washington, D.C. area, performed what appeared to be a bit of magic. They increased the yield in their water supply systems by nearly 50 percent using sophisticated computer-based river modeling techniques. The focal point of this effort was the Interstate Commission on the Potomac River Basin. Cooperative management of the river basin by two States, a city, two local utilities and a Federal water agency helped solve regional water supply problems for at least 50 years at a cost savings of between $200 million and $1 billion below previously proposed solutions.[1]

With periodic drought conditions and increasing populations, the water supply planners were faced with immense problems. Proposed solutions had included as many as 16 new reservoirs. Yet, by cooperative, improved operations assisted by computer-based modeling techniques, the system's yield was increased with only one reservoir and eight operating agreements among the cooperating agencies.

This example represents a potential breakthrough in the way water resources are managed. It may challenge our conventional notions about conflict and cooperation in the water resources arena.




POTOMAC RIVER BASIN

Conventional Wisdom versus Fact

"Die-hard" concepts that are no longer true often affect management decisions. Is it true, for example, that possibilities for new water uses decrease as development increases along the river system? What we have discovered over the years is that there is a point in the development of a river system when the physically "interconnected" nature of its operating components provides significant increases in flexibility so that the benefits of the system as a whole exceed the sum of the benefits to its components. Irrigation canals, for example, could be used to absorb flood flows or to produce hydropower, and a number of single purpose reservoirs could be cooperatively managed to increase system yield.

In the Northwest's Columbia River Basin, as long ago as the 1940's, a bitter political struggle between public utility districts, investor-owned utilities, Federal agencies and the Canadian government threatened peaceful relations among the interested parties and undermined economic growth. The struggle evolved into a cooperative relationship during the 1960's when it became clear that no single entity could finance the large dams and ancillary facilities needed for productive joint use of the river. A large interconnecting power grid now exists to serve public and private distribution systems. In addition, the grid is connected to portions of California, thus linking southern air-conditioning requirements in the summer and northern heating requirements in the winter to make more efficient use of hydroelectric generating capacity.

The cooperative arrangement in the Columbia River Basin provided an ideal opportunity for the use of high technology. Annual operating plans and advanced computer simulation models obtain the maximum power generation possible while fulfilling non-power needs. Cooperation among potential competitors can lead to benefits for every competitor that exceed those available from independent operations.

Are legal and institutional requirements barriers or impediments to effective river management? The belief that they are has been another bit of conventional wisdom that needs a second look. Existing laws, regulations and court decisions clearly limit what can be done by river managers. Because they are so numerous and often in conflict, these legal and institutional factors seem overwhelming. The availability of computers, however, better enables river managers to factor in legal and institutional requirements and to identify river management options.

Perhaps conventional wisdom should be replaced by a new set of principles: (1) The physical interconnectedness of heavily engineered river systems makes possible many options for solving water problems; (2) Intense competition for water should provide the incentive to go beyond traditional solutions and solve problems through cooperative, innovative management, and (3) Computer technologies provide an effective tool to make use of available options to satisfy water users in a river basin within existing laws and management requirements.

The management technologies available today will improve over time and be even more valuable as demands on limited water supplies increase. For this reason, it is all the more important for water managers to begin utilizing technology to their advantage. Doing this will not only help today's water managers meet today's needs, it will position tomorrow's water managers to anticipate and avoid many of tomorrow's problems.

Technological Advances

A recent survey by the Office of Technology Assessment[2] found that the development of models by Federal agencies for water resources planning, management and policymaking has grown rapidly in recent years and that a number of States have begun to make use of some of these. Agencies such as the U.S. Army Corps of Engineers and the Bureau of Reclamation have initiated aggressive efforts to apply the most recent advances in water systems modeling to the operation of reservoirs and water delivery systems and to assist water districts with farm irrigation scheduling. Examples of successful applications of new river management approaches based on the newly developed technology are discussed below.

Use of mathematical modeling in the Central Valley Project in California[3] has resulted in significantly improved operations in the last four years and now forms the basis upon which all operations decisions are made. Within the last year, the Tennessee Valley Authority has placed into operation a daily routing model of the entire Tennessee River Basin. Use of this model has already resulted in improvements in the efficiency of releases for flood control and hydroelectric power production.

Challenges

We have the technology to manage for floods and for drought; for water conservation and maximum yeild; to optimize benefits and provide for instream flows.

But the effective use of the technology for these purposes requires a concerted effort on the part of all those who have a part in managing a river system. We may have to discard some old ideas of what our limitations are. We may have to bury our differences. We may have to share in making decisions that once were ours alone. We need not lose anything in the process.

We simply need to ask the question, how can we better manage our rivers to achieve new goals? State legislators may wish to define State policy objectives and establish criteria for effective management. River managers may wish to look for ways to accommodate new water uses, such as instream flows concurrent with other uses. Individual States should take the lead in organizing a collective effort.

Resolving Interstate Water Conflicts

The Issue: **Laws and institutions that historically have allowed States to control the allocation and use of waters within their borders are being challenged, making it difficult for States to deal with water problems.**

The Problem

The key element of the Reagan Administration's water policy is that States have the primary authority and responsibility to allocate and manage water resources within their boundaries. Congress has established a pattern of deference to States as the primary agents for controlling water appropriations, including, beyond the confines of Federal reserved water rights, water on Federal lands. The Mining Act of 1866, the Desert Lands Act of 1877, the Reclamation Act of 1902 and other Acts defer to State laws for water appropriations. The McCarran Amendment in 1952 permitted the United States to be joined as one of the parties in general State stream adjudications, along with the other water right claimants.

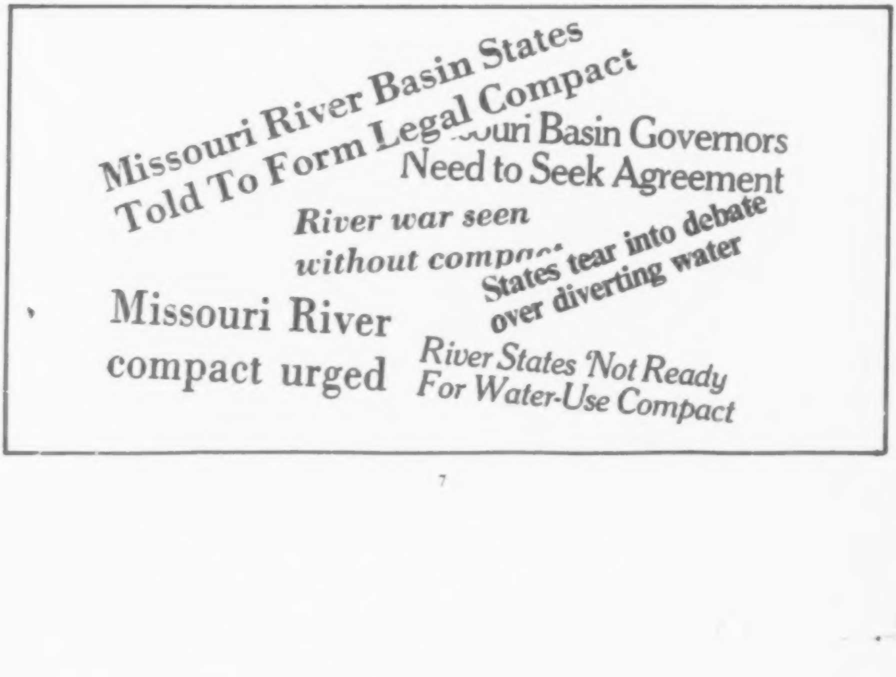
However, a series of events over the past year and a half has left many observers wondering just what powers the States do have in allocating and managing water resources.

Recent Court Decisions

A decision by the U.S. Supreme Court in July of 1982, *Sporhase v. Nebraska*,[1] determined that water was an "article of interstate commerce" under the venerable Commerce Clause of the U.S. Constitution. By this decision, the Court placed limits on the ability of a State government to restrict the export of its waters beyond State boundaries. The case began quietly enough. Two farmers purchased contiguous property divided by the Colorado-Nebraska boundary. Nebraska ground water was used to irrigate land in both States. The farmers did not apply for a permit to transport ground water to another State, as required by Nebraska law. Had they done so, the permit would have been denied because Nebraska law provided for such permits only if the other State allows its ground water to be exported to Nebraska. Colorado law made no such provision.

In *Sporhase*, the Supreme Court held Nebraska's reciprocity requirement to be unconstitutional on the grounds that ground water is an article of interstate commerce and, as such, burdens on its interstate movement may be permissible only if they are related to specific management objectives, like water conservation, and if they are imposed on all water users equally.

After the *Sporhase* decision, attention within the water community focused on an unrelated but similar case in the Southwest. In this second case, New Mexico law prohibited the transport of New Mexico ground water beyond the boundaries of the State. El Paso, a Texas city on New Mexico's southern boundary, filed 326 applications for ground-water withdrawals. The New Mexico State Engineer denied all 326 permits and was then challenged in the Federal District Court by El Paso. In January of 1983, the Court held that a total ban was an unreasonable restriction on interstate commerce; the Court also found New Mexico's ban on water exports to be discriminatory because it treated in-State and out-of-State water users differently. *El Paso v. Reynolds*[3] was the first significant ruling on a water issue to follow *Sporhase* and was thought by some to presage how other Federal judges would interpret the *Sporhase* decision in future water cases.



Missouri River Basin States Told To Form Legal Compact

ouri Basin Governors Need to Seek Agreement

River war seen without comp

States tear into debate over diverting water

Missouri River compact urged

River States 'Not Ready For Water-Use Compact

These decisions will clearly impact on the ability of State governments to manage and allocate their own water resources. State regulations of water resources will need to recognize basic Constitutional limitations. Appropriate health, safety and welfare grounds must be present before a State can regulate interstate shipments of ground water, and any such restrictions cannot discriminate against out-of-State users. However, to what extent can States prevent or control the use of their water out-of-State? The answer remains unclear even after the *Sporhase* and *El Paso* rulings. Continuing litigation on this subject area will result in partial answers to some of the questions currently in dispute.

Cases on the Horizon

The State of South Dakota recently reached an agreement with the ETSI Pipeline Company for the sale of up to 50,000 acre feet of water per year from the main stem of the Missouri River. Some of the water would be used by ETSI for a coal slurry pipeline from Wyoming to Arkansas. Because the water is stored behind a Federal dam, it was necessary for the Department of the Interior to sign the contract. The States of Iowa, Nebraska and Missouri sued to block the contract. In the meantime, ETSI plans to begin construction early in 1984, although the recent loss of an important contract may postpone that date.

Unlike *Sporhase* and *El Paso*, in the ETSI case a State is defending its authority to sell water for out-of-State use. Downstream States feel threatened since the water will be moved to an entirely different basin and not be available to them. This case also differs from the others in that this conflict is over surface water, which has a more obvious relationship to State boundaries than does ground water.

Unlike some other major river basins (such as the Colorado), the Missouri River has no interstate compact that apportions the available water to the surrounding States. As a consequence, the ETSI contract has generated interest among Missouri River Basin States in an interstate compact or some other interstate arrangement. Bills were introduced in 1982 and 1983 to grant the consent of Congress to the negotiation of an interstate compact.

Federal efforts to solve interstate problems are often predicated on the argument that the States won't take necessary actions without Federal "guidance" and aid. This attitude generated much of the Federal government's explosive growth over the past several decades. The Reagan Administration strongly supports State primacy in the allocation and management of water resources and will vigorously oppose efforts to impose a Federal presence into decisions that should rightfully be made within and among the States involved.

Interstate compacts offer a well proven mechanism for resolving interstate disputes about water. Nevertheless, the *Sporhase* and *El Paso* decisions raise questions about the legal capacity of compacts to take actions that would be prohibited if taken by individual States. Could an interstate compact, for example, limit or regulate the transport of water out of a river basin? Because an interstate compact has no effect unless ratified by Congress, couldn't compacts exercise limits on water export not available to individual States under the *Sporhase* and *El Paso* doctrines?

Even these questions are now in Court. Two current cases challenge the provision of the Yellowstone River Compact that says: "No water shall be diverted from the Yellowstone River Basin without the unanimous consent of all the signatory States." The trend in these cases is an apparent erosion of States' abilities to control the use of waters within their boundaries. Depending upon the outcome of the challenges to the Yellowstone Compact, the erosion might extend to limiting the ability of States to act in concert through the interstate compact process.

State Reactions

Before *Sporhase* and *El Paso*, the laws of at least 14 States (Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Jersey, New Mexico, Oregon, Utah, Washington and Wyoming) prohibited or otherwise limited interstate ground-water shipments. Since the decisions, the State legislatures of New Mexico and Colorado modified their laws to conform to the requirements set forth by the Court. The Nebraska Supreme Court has severed from the State statute the wording declared unconstitutional by the Supreme Court in the *Sporhase* decision.

Challenges

Perhaps the greatest importance of these Court cases will be that they catalyzed the States into developing aggressive and affirmative water management programs to deal with the new demands placed upon them.

The two areas of opportunity are:

- The rewriting of State water laws and the realigning of State water administration consistent with the laws, according to the emerging requirements set forth by the Courts.

- The negotiation of interstate compacts for surface and ground water to accomplish the management objectives sought by the States.

Water Project Development

The Issue: While water project benefits are key components of national economic well being, budgetary pressures have made it important to identify the most economically efficient and financially attractive alternatives and to find new mechanisms for water project financing.

The Problem

Three facts vividly illustrate the severe water project funding dilemma facing the Nation:

- A $60 billion backlog of authorized projects,[6]
- A $113 billion need for water rehabilitation over the next 17 years,[7]
- $200 billion annual Federal budget deficits.

Policy Trends

Federal water project financing and cost-sharing policy has developed incrementally over the years through a series of Congressional enactments. Current policy is embodied in the Reclamation Act, Flood Control Acts, Rivers and Harbors Acts, the Watershed Protection and Flood Protection Act of 1954, Water Supply Act of 1958, Fish and Wildlife Coordination Act of 1958, Water Protection Act of 1965 and various specific project authorizations and appropriation acts.

Although the Federal government has historically assumed a large role in water project financing, non-Federal (and in some cases, non-public) entities have been even more active. Thousands of "water districts" of various types came into existence in this century, most with revenue raising authorities. Together with State and local governments, especially cities or municipalities, these entities currently spend about $14 billion annually on water development, including expenditures for municipal and industrial water supplies.

Federal Actions

The Reagan Administration has moved aggressively to improve the ways in which water projects are planned, funded and managed:

- A new set of water project planning procedures was established in early 1983 to guide the planning activities of the Bureau of Reclamation, Corps of Engineers, Soil Conservation Service and Tennessee Valley Authority. These *Principles and Guidelines*[8] were designed to help identify economically attractive projects, reduce planning costs and incorporate State and local concerns into the planning process. They have replaced a lengthy set of burdensome and inflexible regulations with non-regulatory planning guidelines.

- A new "two-phase" planning process was established in the Bureau of Reclamation. This process has a potential for reducing time requirements for project planning from an average of seventeen to an average of seven years.

- The President submitted twenty-four new water projects starts for the Bureau of Reclamation and the Corps of Engineers in FY 1983 and 1984. These projects reflect strengthened Federal/non-Federal partnerships and substantially lower Federal costs.

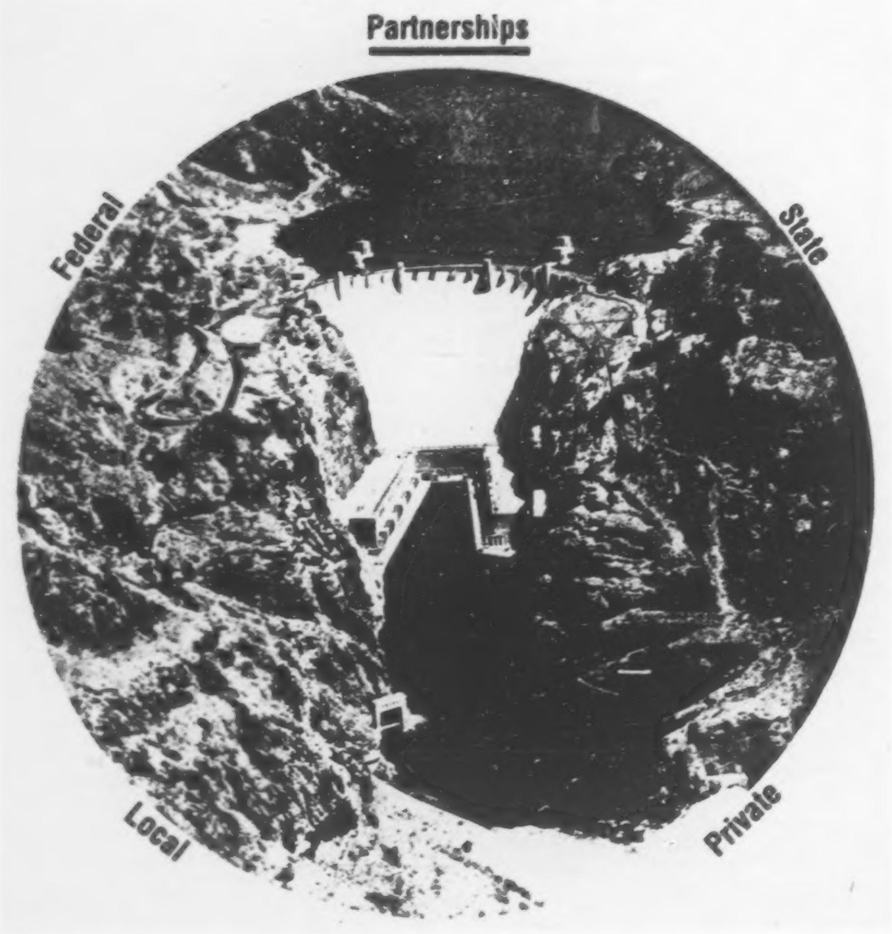
- Interior Department officials worked successfully with the Congress to enact the Reclamation Reform Act of 1982. This major milestone removes uncertainties surrounding the acreage limitations issue, limits the amount of Federally subsidized water any individual can receive and enhances the economic viability of Federal projects.

- A new policy of increased non-Federal participation in project financing, consistent with the abilities of non-Federal sponsors to participate financially and in conformity with prior Federal commitments, was adopted by the President's Cabinet Council on Natural Resources and Environment. This new policy was approved after extensive interaction with the Congress, Governors, the water community and the public and permits flexibility for future changes. It has established a basis for new partnerships between Federal and non-Federal project sponsors.

State Actions

In the West, many States are responding emphatically and, in many cases, innovatively to the need for water development. Nebraska, for example, in 1983 passed legislation that allows the establishment of a program to finance the development of ground-water recharge reservoirs by using pumping fees to retire revenue bonds. The Colorado General Assembly created a Water Resources and Power Development Authority in 1981 and appropriated $30 million to start a project development fund. The Wyoming Legislature appropriated $47 million in 1982 to contribute to the construction of a major Bureau of Reclamation project. Arizona and Minnesota have recently established task forces to find new ways of providing water project funding. Other Western States have also demonstrated ingenuity in seeking ways to finance needed water projects.

Eastern States have also responded. In 1981, New Jersey voters approved a $350 million bond issue for rehabilitation and construction of water supply facilities. Under a 1983 North Carolina law, 40 percent of the revenue from a new local option sales tax is to be devoted to water or watershed projects. In 1982, the Massachusetts legislature established $333 million in new bonding authority for water system rehabilitation and water quality protection.



Partnerships: The Federal government historically has been associated with construction of large water projects, such as Hoover Dam (above). Nevertheless, most projects benefit State and local water users — private as well as public. The Reagan Administration is committed to a true partnership in needed water development, under which those who benefit would share in the planning, construction, operation and management of the projects.

Other Proposals

In the past few years many new and sometimes controversial ideas have surfaced. Some have recommended that the Congress establish a **national water development bank** to finance non-Federal shares of Federally constructed water projects. The bank could be under Federal charter or have tax exempt foundation status and would provide loans to non-Federal project sponsors, repayable from project revenues, perhaps supplemented by State appropriations. This approach could avoid State constitutional debt limitations, referendum requirements, and other State and local financing restrictions. It could provide features not available in the private banking system, such as extended repayment periods and water project analytic expertise, and could be effective in focusing increased attention on financially profitable projects. Others have suggested that such an approach be pursued at regional or State levels.

Another concept that has received attention recently involves the establishment by Congress of **special tax treatments** of water development bonds to be issued by Federal, State or local governments or corporations. A wide variety of changes has been suggested to reduce borrowing costs by providing special exemptions from Federal income and inheritance taxes and similar taxes, or through interest subsidies. This approach could reduce non-Federal costs of capital and could enable non-Federal project sponsors to attract investors from outside project areas. Reduced non-Federal costs of borrowing, however, would be balanced by a loss of Federal tax revenue unless non-Federal sponsors contributed a higher share of project costs as part of such an arrangement.

The establishment of a new program of **loan guarantees** is another suggested approach in which the Federal government would guarantee State and local water project loans and bonds to enable these non-Federal project sponsors to raise capital at below market interest rates. Although this would enhance the ability of non-Federal project sponsors to raise investment capital, it would increase competition among existing highgrade bond instruments, putting upward pressure on interest rates.

Yet another concept is to replace the current project-by-project funding process with **block grants** for intrastate projects, leaving the traditional approach unchanged for multi-state projects. This could allow States to compare needs across major water programs (urban water system rehabilitation vs. new irrigation projects vs. dam safety, etc.), would place sole responsibility for solving local water problems on State and local governments and could accelerate the construction of interstate projects. However, a block grant approach could result in expenditures of Federal funds for projects previously paid for by non-Federal funds. In addition, it would require a funding allocation formula, which would be highly controversial and could be burdensome to low income States if high matching requirements were set.

These examples illustrate some of the concepts being discussed currently at various levels of government. A myriad of variations, combinations and other ideas have appeared in recent years. Alternative means of project financing will be important to continued Federal water project planning and development.

Challenges

The changing nature of water development means that States take a lead role. They may wish to evaluate their future water requirements and establish priorities for the most needed projects. They may wish to establish State water development funds for use as seed money to speed the construction process. Clearly, those States that take the initiative will be in a strong position to influence water development by the Federal government and non-Federal water developers.

Indian Water Claims

The Issue: **At the Federal and State level, there is increasing reliance on negotiation, rather than litigation, as the vehicle for resolving Indian water claims. Negotiation offers the potential for more expeditious and cost-effective settlements consistent with local conditions.**

Background of Indian Reserved Water Rights

In a series of decisions dating from *Winters v. United States*, 207 U.S. 564 (1908), the Supreme Court has held that when an Indian reservation is established, water from appurtenant sources is reserved to fulfill the purposes for which the reservation was established. The reserved rights (or Winters) doctrine applies to all Indian reservations whether established by treaty, statute or executive order.

Under the Winters doctrine, the reserved right applies to water sources that are unappropriated at the time the reservation is established. The reserved right need not be perfected by actual, beneficial use. It vests at the time of reservation and cannot be lost by nonuse.

Reserved rights have been quantified in some cases on the basis of "practicably irrigable acreage." The rights also have been quantified in terms of fishery maintenance requirements. Other bases for quantification being litigated in a number of cases include water for mineral resources development, municipal and industrial needs, aesthetics, wildlife management, recreation, livestock and domestic uses.

The necessity for maintaining the Indian reservation as a permanent tribal homeland is the determining factor for selecting the appropriate bases for quantification of a particular reservation's water right.

Quantification of Water Rights

Reserved water rights generally are quantified either through litigation or negotiation. Litigation heretofore has been more frequently used than negotiation. In 1952, Congress enacted the McCarran Amendment (43 USC §666) which waived the sovereign immunity of the United States to suits brought for the general adjudication of water rights. The waiver removed Federal barriers to such suits, whether brought in State or Federal courts. The Supreme Court confirmed in 1976 and again in 1983[9] that the waiver of sovereign immunity applies to cases in which the United States is named as trustee for the reserved water rights of Indian tribes, even where those tribes have not waived their own immunity from suit.

A general adjudication of water rights is a complex process requiring the determination of the nature and extent of the respective water rights of all users. Most private uses of water in the West occur pursuant to State law under the appropriative rights system. The primary element of the appropriation doctrine is that the first user to appropriate water for beneficial use enjoys the first right to water in time of shortage. The reserved rights doctrine is wholly a product of Federal law and does not rely on State law or procedures for its existence. The legal and practical differences between appropriative and reserved rights can make adjudication of both in the same proceedings a complicated and time-consuming process.

Table 1. Lands Under Jurisdiction of the Bureau of Indian Affairs in the 17 Western States

State	Acres of Indian Lands	Percentage of State Lands
Arizona	19,897,000	27.4
South Dakota	5,096,000	10.4
New Mexico	7,459,000	9.6
Washington	2,499,000	5.9
Montana	5,240,000	5.6
Utah	2,286,000	4.3
Wyoming	1,888,000	3.0
Oklahoma	1,222,000	2.8
North Dakota	853,000	1.9
Nevada	1,225,000	1.7
Idaho	826,000	1.6
Oregon	760,000	1.2
Colorado	756,000	1.1
California	569,000	.6
Kansas	29,000	.1
Nebraska	65,000	.1
Texas	0	0

Note: The quantity of Indian water rights, a function of many factors, is not necessarily proportional to Indian land area.

Source: Bureau of Indian Affairs.

Two cases illustrate how time-consuming the process of stream adjudication can be. *Arizona v. California*[10] was first filed in 1952. In 1964, the Supreme Court issued a decree that allocated Colorado River water among three States and decreed the water rights of five Indian tribes. In a supplemental proceeding filed in 1979, the United States, as trustee for those tribes, sought water rights for additional reservation lands. The Supreme Court, relying on principles of finality, held early in 1983 that the 1964 decree would stand, largely unchanged. However, the Court held that a portion of the Indians' additional claims for water could be adjudicated, leaving unresolved the full extent of the Indian claims, even after a period of 31 years.

Nevada v. United States[11] is a second example of uncertainty over water rights continuing over a period of decades. In 1913, the United States filed what is known as the *Orr Ditch* litigation to adjudicate water rights to the Truckee River for the benefit of the Pyramid Lake Indian Reservation and the Newlands Reclamation Project. Eventually, in 1944, the Federal District Court entered a final decree awarding various water rights to the Reservation and the Project.

In 1973, the United States again filed suit on behalf of the Tribe, seeking additional rights to the Truckee River and its tributaries in Nevada. In June, 1983, the Supreme Court, again relying on principles of finality, ruled against the United States and the Tribe. This final decision was rendered seventy years after the filing of the initial lawsuit.

Obviously, while Indian water claims remain unadjudicated, existing water users are uncertain about the validity of their water rights, water managers cannot establish how much water is available for further appropriation, and Indian tribes are without the means to develop reservation resources.

Administration Policy

The Interior Department is currently involved as trustee in more than 50 Indian water rights cases. Litigation of these cases has proved to be a time-consuming and expensive process for all parties involved. A major policy initiative of the Reagan Administration has been to promote more timely and cost-effective settlements through negotiations involving all interested parties. To this end, Secretary Watt appointed a special Indian water claims negotiating team in July 1982.

The first major Indian water rights settlement of this Administration was reached with the enactment of the Southern Arizona Water Rights Settlement Act of 1982 (P.L. 97-293). An earlier settlement, representing a consensus only among the Papago Tribe and local water users, was passed by the Congress. However, President Reagan vetoed the bill because the United States government was not a party to the negotiations but would be required to bear almost the entire burden of financing the settlement. Following the veto, the Interior Department's negotiating team worked closely with the Tribe, State and local officials and the non-Indian water using community. A new agreement was reached in which the affected parties shared in the cost of the settlement, at a significant saving to taxpayers. Officials of the Interior Department, and the non-Federal parties recently executed contracts required by P.L. 97-293 to implement the settlement.

There are other examples of negotiating successes. An agreement in principal has been signed with the Ak Chin Indian community implementing P.L. 95-328 and providing for delivery of a permanent water supply. This agreement will be pursued in cooperation with State and local entities. The Interior negotiating team has also been working closely with the Fort Peck Tribe and the State of Montana toward a negotiated settlement. Negotiations are currently under way with several other tribes.

State Reactions

Although litigation over Indian water rights is pending in States throughout the West, some States have concluded that general stream adjudications are not a convenient method for quantifying Indian water rights. For example, litigation of reserved rights was begun by the State of Wyoming in 1977, and adjudication of the Indian claims is nearly completed. However, the State has invited the Indians and the United States to consider a negotiated settlement of the remaining Indian reserved rights claims. A negotiated settlement has already been reached between the State and the United States on non-Indian Federal reserved rights claims.

In the late 1970's, Montana established a commission to negotiate reserved water rights. The State has been negotiating water rights with several tribes, with the cooperation and participation of the Interior Department. South Dakota recently moved to dismiss the adjudication it had filed on the Missouri River for quantification of Indian and other Federal reserved water rights claims in the State.

Challenges

The need to resolve Indian water claims fairly as demands for scarce water supplies increase is a strong incentive to both Indian and non-Indian water users. Negotiated settlements can relieve the uncertainty caused by pending adjudications and provide for timely development of Indian and non-Indian water resources. Successful negotiations require the close cooperation of Federal, tribal, State and local entities to ensure cost-effective solutions consistent with local needs. Accordingly, the Interior Department is prepared to participate in and facilitate water-rights settlement initiatives from States and Indian tribes.

Water Quality

Despite major improvement in most watersheds, water quality issues continue to be a special concern in the United States. While the Environmental Protection Agency has primary responsibility for enforcing clean water laws and regulations, the Department of the Interior plays an important role in protecting the quality of our Nation's water resources. The U.S. Geological Survey monitors and reports on surface- and ground-water conditions. The Bureau of Reclamation plays an important role in the monitoring and control of saline contamination of Western surface- and ground-water supplies. The National Park Service, Fish and Wildlife Service and the Bureau of Land Management have conducted several water studies on public lands. Two water resources problems have been chosen for review: acid rain and salinity, both of which have claimed increasing attention in recent years.

Acid Rain

The Issue: **Popular opinion, spurred by recent press coverage, is calling for action to mitigate the impacts of acid rain. It is unclear whether proposed "cures" would in fact be successful in reducing the impacts of this atmospheric phenomenon.**

What Is Acid Rain?

"Acid Rain" is a term commonly used to describe a variety of pollutants deposited in wet and dry form.

In the *National Water Summary* the Geological Survey reports that 24 States are concerned about the potential contribution of acid rain to surface water acidification. These States are located primarily in the Northeast, Southeast, and Far-West. Several States, including Pennsylvania, New York and West Virginia, have even initiated legal action against neighboring States to control air pollution that crosses State boundaries. The true nature of acid rain must be understood before workable policy commitments can be made.

Substances may be generally classified as acid, neutral or alkaline. On the logarithmic pH scale, a pH of 7 is neutral (neither acid nor alkaline). Any number less than 7 is acidic, with zero meaning highest acidity. For comparison, lemon juice falls at about 2.2 on the pH scale. Values above 7 indicate alkalinity, with 14 being the most alkaline. Normal rainfall is slightly acid. What is commonly referred to as acid rain has a pH value of lower than 5.6, although particles in the atmosphere can shift that value either way.

Causes of Acid Rain

Why don't we do something about eliminating the causes of acid rain? Actually, the solution to the problem is not simple.[12] If we were dealing with a known cause-effect relationship, we could go directly to the cause. Unfortunately, there are many causes. The most widely publicized cause of acid rain is the burning of fossil fuels such as coal and oil, which contain sulfur. As they are burned, they produced sulfur dioxide and nitrogen oxides that may convert to sulfates and nitrates and/or acids when they react in the atmosphere. These acids are carried by prevailing winds and are eventually deposited on the earth as rain or snow.

But this is only part of the story. There is evidence from ice core analysis of acidic periods existing long before man began burning fossil fuels.[13] Other causes of acidity in our waters include mine drainage and a host of natural factors. Furthermore, even when acid rain occurs, it does not have the same effect on all waters. Lakes and watersheds exhibit a wide range of sensitivity to acidification. Included among these factors are the acidity of the rain itself, the hydrology of the lake or watershed, the acidity of the soil system, and the resultant chemical intermixing with surface water. Thus, with a given amount of acid rain, some waters can exhibit serious adverse impacts such as declining fish populations, and other waters can show almost no adverse effects.

There is disagreement within the scientific community about both the causes and the impacts of acid rain. While a consensus seems to be developing linking acid rain directly to fossil fuels, wide disagreement remains about the long-range significance of the phenomenon. There is wide disagreement on an appropriate solution. Some favor a relatively small-scale solution like putting lime in highly acidic bodies of water. Others urge a multi-billion dollar program to put "scrubbers" on fossil fueled utility plants. This range of views will presumably narrow as more is learned about acid rain.

The Federal Response

Any attempt to reduce the impacts of acid rain will not be without cost. Unfortunately, we know very little about whether any particular reduction in emissions will result in a corresponding reduction in impact on the other end. For this reason, the Reagan Administration has currently chosen a policy of accelerated research to seek out the answers. Several additional options, most of which include a reduction in sulfur dioxide emissions, are currently being considered.

Through the Interagency Task Force on Acid Precipitation, the Reagan Administration is implementing a comprehensive research program. At the request of the Administration, funding for the research program has been doubled since 1980, from $11 million to over $22 million, with further increases expected over the next two years.[14]

While the primary Federal responsibility for water quality management programs rests with the Environmental Protection Agency, the Department of the

Interior has important research and monitoring responsibilities. Various bureaus within the Department are active in: studying the nature of atmospheric dusts, gases and solid materials emitted by volcanoes and geysers; providing standards of quality assurance for the chemical analysis of atmospheric deposition; investigating the rate of vertical mixing and cloud conditions under which rainout of various materials occurs; developing mathematical models of atmospheric transport; operating monitoring sites for collecting acid precipitation samples; studying the effects of acid rain; developing rainfall-runoff models, and supporting research on the chemical changes in precipitation passing through terrestrial ecosystems.[15]

The State Response

Minnesota, California, Wisconsin and Massachusetts have undertaken the most aggressive acid rain programs. Minnesota has passed acid rain legislation that establishes a timetable for identifying sensitive land and water resources, establishing acid deposition standards, and developing an emissions control program for various sources of emissions. California and Wisconsin have initiated substantial acid deposition research programs. Massachusetts adds lime to ponds to sustain stocked fish and treats some acidic waters to reduce corrosion.

Challenges

The Reagan Administration is studying the full range of options concerning acid rain. Governments, generally, must make two difficult decisions. The first is a decision about the actions Government can take to avoid acid rain and/or to mitigate its impacts. As mentioned earlier, such options range from the simple and relatively inexpensive to the complex and very expensive. The second decision is who—what group of Americans—should pay for these actions. Is it equitable to distribute the costs among all taxpayers, even if most of them neither contribute to nor suffer from the problem? Should we tax fossil-fueled utilities to pay for mitigation and clean-up? If so, should we tax the utilities that burn low-sulfur coal at the same rate that we apply to utilities using high-sulfur coal? These are just a few of the factors policymakers must consider as we come to grips with the problem of acid rain.

Salinity

The Issue: Most water uses depend on good quality water with low salt content. The increasing salinity of some of our inland and coastal water supplies, however, is effectively reducing usable supply, thereby creating a series of local/regional problems.

What Is Salinity?

As reported in the *National Water Summary 1983*, nearly one-half of the States are concerned about possible increases in the salinity of ground water as the result of ground-water withdrawals. Twelve States are concerned about the adverse effects of salinity on surface-water quality. Although salinity has not really become a major national issue, it is an important problem in some areas. Along the coastal regions of the United States, many municipal water suppliers are experiencing intrusion of salt water into their ground-water supplies. In some cases, development may have to be curtailed to prevent salt water intrusion. The problem may require the use of alternative water supplies, the pumping of freshwater back into the aquifers, developing freshwater barriers, or reduction of ground-water withdrawals.

Local problems take on interstate dimensions in areas such as Savannah, Georgia, where extensive pumping is also causing salt water intrusion in the neighboring Hilton Head Island resort in South Carolina.

Salinity takes on a regional/national dimension when it affects major economic development, such as oil shale and mineral development in the Colorado River Basin. Many aquifers in this region contain heavy concentrations of salt. When the aquifers are excavated during mineral extraction, disposal of the salty water poses a serious dilemma.

Salinity is an international issue along the Colorado River. In 1944, a Treaty between Mexico and the United States allocated to Mexico a portion of the Colorado River along with other waters. In 1962, Mexico claimed that salinity in the River was damaging its cropland. While the Treaty itself was silent on the subject of salinity, an agreement between the American and Mexican sections of the International Boundary and Water Commission called for actions on the part of the United States Government to prevent salinity levels of the water going to Mexico from exceeding by a given fixed amount salinity levels of water going to the last American users north of the border. Even now, the fulfillment of U.S. obligations to Mexico for delivering high quality water presents enormous problems.

The Federal Response

The design and implementation of water quality standards for all freshwater contaminants remains the general responsibility of the Environmental Protection Agency through such Federal legislation as the Clean Water Act and the Safe Drinking Water Act.

The Interior Department's Bureau of Reclamation has been conducting research on saline contamination since 1950 and successfully completed the first demonstration plant for desalting in 1965. Saline contamination continues to be a significant issue for the Bureau as it balances irrigation problems in the use of reclamation project waters with the requirement for delivering quality water to Mexico. The Bureau is the lead agency in the construction of what will be the world's largest desalting complex at Yuma, Arizona, which is being constructed to desalinate water destined for Mexico.

On Capitol Hill, legislation has been introduced into the 98th Congress to provide, among other things, for the continued research and development of technologies to convert saline and other impaired waters to a quality suitable for municipal, agricultural and other related uses. Other proposed legislation would amend the Colorado River Basin Salinity Control Act to assure the attainment of the salinity standards that were adopted by the Colorado River Basin States and approved by the Environmental Protection Agency in 1975. The Interior Department recognizes the salinity problem on the Colorado River and the need for cost-effective controls for salinity abatement.

State Responses

Except for the role of the Bureau of Reclamation in desalting and salinity control in the Colorado River Basin and other Federal research activities on desalting alternatives, much of the responsibility for solutions falls on local governments and municipalities. One State effort is particularly worthy of note. In 1983, the New Mexico State Legislature appropriated $500,000 to the State's Water Resources Research Institute at New Mexico State University for a salinity research program. The study will be aimed at developing field and greenhouse crops that are tolerant to salts in the water. In addition, the research will evaluate the use of brackish water for the growing of fish, shellfish and algae in an aquaculture setting.

What does the Future Hold?

The issue of salinity will, in all likelihood, not become a serious public issue except in a few local/regional areas. Nevertheless, because saline contamination directly affects the end use of our waters, it can potentially cause serious water supply crises in the future. Long-term contamination of ground-water aquifers may result in permanent damage. Desalinization alternatives are prohibitively expensive under current technology.

The control of salinity intrusion will require a concerted effort among the Federal, State and local governments. The most notable State and regional efforts to control salinity have been related to the Colorado River. The Colorado River Basin Salinity Control Forum, a cooperative State/Federal project, has resulted in the following initiatives:

- The adoption of salinity limits.
- The control of natural salinity by pumping or diversion.
- The diversion of saline water for various industrial uses, including a planned coal slurry pipeline.

These initiatives could serve as a model for other State/local jurisdictions to adopt.

Challenges

Any serious assault on salinity problems, whether in surface or ground water, will be expensive and difficult. The Federal government and the States have invested heavily in research, but actions to avoid and/or mitigate salinity will be extremely expensive. The Yuma desalinization facility, for example, may cost several hundred million dollars. Efforts to decrease salinity levels from "non-point" sources such as farms and feedlots may be both expensive and difficult to implement.

As with acid rain, difficult decisions must be made on programs to avoid salinity and to ameliorate its impacts. Like acid rain, salinity often reflects man's activities. Unlike acid rain, however, a large fraction of all salinity is "natural" and is not caused by man. Man's solution, as far as this country is concerned, must come about through combined governmental and private efforts.

Footnotes

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2. Office of Technology Assessment, *Use of Models for Water Resources Management, Planning and Policy.* (U.S. Government Printing Office, Washington, D.C.,1982).
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9. *Arizona v. San Carlos Apache Tribe of Arizona,* 51 U.S.L.W. 5095 (July 1, 1983).
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Illustrations*

Inside front cover: Parker Dam, Colorado River
Page 1: Columbia Basin Project **Harvey Doerksen, Department of the Interior**
Pages 4 and 5: Photograph and map from Interstate Commission on the Potomac River Basin
Inside back cover: Grand Coulee Dam, Columbia River

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CURRENT WATER ISSUES

by
Kenneth D. Frederick

FOR most of this century, abundant, low-cost supplies of high quality water have been taken for granted in the United States. Even in arid regions water has been inexpensive and available to support rapid, water-intensive development. Seldom has water been treated as a scarce resource to be shared among competing uses. Attention turned to water only when problems arose. And the problems that did arise were generally attributed to "acts of God," such as drought and floods, that could be solved with another water project.

Water problems have become increasingly newsworthy in recent years, and they no longer are readily attributable to divine causes. Reports of declining groundwater tables, conflicting demands on water supplies, toxic chemicals in drinking water, polluted rivers and lakes, and deteriorating municipal water systems have become common in the news media. Complacency is giving way to concern and even alarm under a barrage of anecdotal evidence of water problems. Water is now commonly billed as the next resource crisis.

Are we really running out of clean water? Is the nation headed for a water crisis? If so, what can and should we do about it? To answer these questions, we must strive to understand the nature of the resource and how we use it.

Water, water everywhere...

Water is one of our most abundant resources. Precipitation averages nearly 30 inches a year or 4,200 billion gallons per day within the 48 contiguous states. In addition to these renewable supplies, about 150 trillion gallons of freshwater are stored in surface reservoirs, and 200 times this amount is stored in groundwater aquifers within 2,500 feet of the surface (*11*).

The hydrologic cycle makes water a renewable resource. Water in vapor form moves in the atmosphere until it condenses and precipitates in the form of rain, snow, or hail. Solar radiation draws water from all wet surfaces and returns water vapor to the atmosphere. The cycle continues indefinitely. No significant change occurs in the amount of water within the global system. Evaporation leaves behind the salts and other impurities that diminish surface water quality. Unfortunately when the water returns to earth, it may not be pure

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Acid rain is an illustration of this.

The hydrologic cycle also makes the quantity of water highly variable over time and space, which complicates the capture of precipitation for human use. In fact, almost two-thirds of all precipitation is quickly returned to the atmosphere through evaporation and transpiration. Only the remaining 35 percent of precipitation (1,450 billion gallons per day in an average year) is considered potential supply.

Assuming average precipitation and 1975 demand levels, 91 percent of this potential water supply ends up flowing into the oceans or the Gulf of Mexico, 2 percent evaporates from reservoirs or flows to Canada or Mexico, and 7 percent is consumed, that is, withdrawn from a surface or groundwater source for offstream use but not returned to such a source (*11*). Consumptive use, however, measures only a small part of our water use. Much of the water that eventually flows to saltwater bodies or to our neighbors is put to use, perhaps several times, before reaching these destinations. Withdrawals from surface or groundwater sources for offstream use average more than three times the consumptive use of water. Moreover, instream flows provide beneficial uses, such as navigation, hydropower, fishing, recreation, wildlife habitat, and waste disposal.

Irrigation, which accounts for nearly half of the withdrawals in the 48 contiguous states and more than four-fifths of consumptive use, dominates offstream water use. Irrigation particularly dominates in the West, where 85 percent of withdrawals and 90 percent of consumptive use are for irrigating about 50 million acres. In the East, irrigation of about 10 million acres accounts for 37 percent of consumptive use but only 5 percent of withdrawals. More than half the water withdrawn in the East is for steam electric cooling. Relatively little of this water is consumed, however. Steam electric cooling accounts for but 6 percent of consumptive use in the East and 1 percent of consumptive use in the 48 contiguous states.

Differences in the relative importance of irrigation and steam electric uses account for the major differences in the average regional consumption-withdrawal ratios. Half of the water withdrawn in the West is consumed compared to only 10 percent in the East.

Instream water uses are often complementary in their demands on water. Satisfying the needs of the largest instream water use also provides water for most other instream uses. Estimates of water needs for navigation and fish and wildlife were made for the Second National Water Assessment. In these estimates, the higher figure served as a proxy for instream water needs. Fish and wildlife was the dominant instream need throughout the United States. Total instream needs for this purpose were estimated to be nearly 10 times the level of offstream consumptive use in the 48 states. Throughout most of the East and the Northwest, instream needs are at least 20 times consumptive use, while in eight western water resource regions, instream needs range from 0.5 to 5.7 times consumptive use.

Meeting water demands

Total water use, which is the sum of offstream consumption and instream needs, is about 87 percent of average streamflow. National aggregate and annual averages, however, mask important considerations in evaluating the adequacy of water supplies. Water needs tend to be location- and time-specific, and these needs often do not coincide with the availability of natural supplies.

Largely because of irrigation in the West, water consumption in the region is five times the level in the humid East (*8*). Total water use actually exceeds average renewable supply in four western water resource regions. This indicates that some uses identified in the second assessment are not being met or that stocks are being depleted. A closer look suggests that water use exceeds mean annual streamflow in 24 western subregions covering an area from central and southern California through Nevada, most of Arizona, New Mexico, eastern Colorado and western Texas, Oklahoma, Kansas, and Nebraska. This shortfall in renewable supplies has been met in part by groundwater withdrawals—withdrawals that exceed recharge in an average year by more than 20 billion gallons per day (*11*).

Fluctuations from year to year in supplies and demands also complicate the task of matching supply with demand. In a wet year (one in which the flow will be exceeded in only 5 of every 100 years), streamflows in the 48 states are 159 percent of the average, while in a dry year (one in which the flow will be exceeded in 95 of every 100 years), flows are only 55 percent of the average. Moreover, variations tend to be greater in the nation's drier regions. In the West, excluding the Pacific Northwest, streamflows as a percentage of the annual average range from 188 percent in a wet year to 36 percent in a dry year (*11*). Fluctuations in demand are not nearly as large as those in supply, but both withdrawals and consumptive use tend to relate inversely to precipitation.

The ability to store and transport water partially compensates for the temporal and regional disparities between supply and demand. With existing surface storage facilities, less than half the potential supply of 1,450 billion gallons per day is actually available for intensive beneficial uses in 95 of 100 years (*11*). Although new reservoirs are being added, net additions to storage capacity in the future are unlikely to be great. Sedimentation is reducing the capacity of existing facilities, and both direct and indirect costs of developing new capacity are rising. Most good sites for dams and reservoirs have been developed, making additions to storage expensive. More important, there is now resistance to new water projects because water is valued more for its instream uses and amenities than ever before.

Cost and environmental considerations also pose an insurmountable obstacle to the more ambitious schemes for large-scale and long-distance water transfers. Water is a bulky resource in relation to its value. Without subsidies, the cost of transporting it long distances out of natural channels (particularly uphill) are prohibitive for most uses. For example, the costs of moving water from the Mississippi or Missouri River to farms in the Texas and Oklahoma High Plains, a region where irrigation is depleting about 12.5 billion gallons per day from groundwater stocks (*11*), are many times the value of the water in agriculture (*4*). If allowance is made for the opportunity costs of using the water in its basin of origin, the costs of interbasin transfers are even higher.

Water quality a growing concern

Quality is becoming an increasingly important consideration in assessing the adequacy of supplies for meeting future water needs. Abuse of many surface and groundwater resources makes water quality an issue of growing concern. Our lakes, rivers, streams, and, to some extent, groundwater aquifers have considerable capacity to assimilate wastes. So long as those capacities are not exceeded, waste disposal is not competitive with other nonconsumptive uses of water. But in many areas of the nation, assimilative capacities have been grossly violated by the quantity, persistence, and toxicity of pollutants introduced either intentionally or unintentionally. Deteriorating quality has rendered some water bodies less desirable or even unusable for such purposes as drinking and recreation.

Billions of dollars have been spent over the past decade to return the nation's rivers and lakes to fishable and swimmable quality. Major improvements have been made in the quality of some surface waters, but the results of these efforts have fallen short of legislative objectives. No major improvement in overall surface water quality is evident (2).

Threats to groundwater quality continue to grow, and they will be much more difficult to reverse. The threats come mainly from dumping untreated, uncontained wastes in places where they can move through the soil and into groundwater. Because groundwater is the source of nearly half the nation's drinking water, contamination poses a health hazard if it goes undetected. Communities where drinking water supplies are contaminated face the costly alternative of treating the water or finding an alternative supply.

Efforts to locate potential sources of contamination by the end of 1982 turned up more than 80,000 pits, ponds and lagoons storing industrial, municipal, agricultural, or mining wastes. In addition, more than 16 million septic tanks regularly disperse effluent into the ground (7). Most of these sites are unmonitored.

There is no systematic survey of groundwater quality. Even when toxic chemicals are detected in water supplies, we know little about their long-term health effects. These uncertainties, combined with widely publicized discoveries of contaminated drinking water supplies in several areas of the country, have generated considerable anxiety. As much as 2 percent of the nation's groundwater may be contaminated (6), but much larger quantities are threatened by the ways in which we dispose of our wastes. Clearly, better waste management is needed to protect the quality of important water supplies.

Salinity poses numerous problems. Groundwater pumping in coastal areas may result in saltwater intruding into freshwater aquifers. Drinking water supplies on Long Island and in parts of Florida and New Jersey are threatened by this process.

All irrigation water contains salts, and concentrations increase as water evaporates, is transpired by plants, or passes over saline soils. High concentrations inhibit plant growth. In extreme situations salinity renders land unsuitable for farming. All western river basins except the Columbia have high and generally rising salt levels. Agricultural productivity is threatened on one-fourth to one-third of the West's irrigated acreage (3). Improved farm management practices and use of salt-tolerant crops can help reduce salinity damages, but these practices will not eliminate the problem. Salts can be removed from a field by applying more water to flush them out or, if drainage is poor, by installing drainage to remove saline water from the field. Washing salts off one field, however, may simply transfer the problem to downstream water users. And when the water becomes too saline for use, there may be an expensive disposal problem. In California's San Joaquin Valley, for example, a $1.3 billion drainage system has been proposed for carrying saline waters out of the valley (9). Desalinization is possible and permits reuse of the water, but this process is much too expensive for widespread use in agriculture.

A very different water quality problem comes from precipitation that has become acidified by sulfur and nitrogen oxides emitted high into the atmosphere and carried hundreds of miles before being precipitated out as acid rain or snow. Although it was virtually unheard of a decade ago, acid precipitation is now recognized as a serious threat to the life systems of thousands of lakes as well as to the viability of forests in the northeastern United States and Canada. Recent evidence suggests other regions of the country may also be threatened. The cause of the problem and the precise physical events that produce acid precipitation have been the focus of much scientific and political debate in recent years. Emissions from power plants and factories, and to a lesser extent from automobiles, located hundreds of miles from the threatened regions, are generally recognized as key factors in the process. Adding lime can offset the acidity of lakes, but this is not a practical, long-term solution for saving the thousands of lakes currently under stress or those that will come under stress if emissions are allowed to continue.

Abundance to scarcity

For centuries, demands on our water resources grew apace with the expansion of our population and economy. Little interest was stirred over the adequacy of supplies. Recent decades, however, mark an important transition from a situation characterized by relatively abundant supplies of low-cost, high-quality water to the situation described above, where the quantity and quality of water are matters of growing concern. Several general factors underlie this transition: (a) water withdrawals and consumptive use have begun to exceed renewable supplies in several areas of the West, (b) abuses of water supplies now exceed assimilative capacities in many areas of the nation, and (c) rising instream demands have increased the future costs associated with other uses and abuses of supplies.

While we are not running out of water, we are running out of inexpensive water. Water is now an economically scarce resource in most areas of the nation and will become more so as demands increase, as groundwater stocks are depleted, and as quality declines. Scarcity implies that all demands can no longer be met at zero or very low prices. Alternatively, scarcity suggests that we can no longer withdraw water from or dump effluents into natural water bodies and assume that supplies are so large that no one else is affected. Scarcity, however, does not necessarily imply crisis or even undue hardship for any specific group so long as we can develop a means of allocating scarce supplies among competing uses and limiting the abuse of fragile resources.

A market's failure

Markets and prices are the customary means our society uses for sharing scarce resources. When markets work well, they direct scarce resources to the highest-value uses and provide the necessary incentives for conservation. Unfortunately, water markets seldom operate well. In some cases, they may not even exist.

For markets to work effectively, there must be well-defined, transferable property rights, and individuals must face the full costs and benefits of their use or exchange of the property. The very nature of water resources makes it difficult to fulfill these conditions. First, as noted earlier, the hydrological cycle makes many water supplies fugitive in time and space. Rivers, streams, and groundwater that flow from one property to another are common property resources. They belong to no one until they are withdrawn for use. When ownership is established only by extraction or capture, the individual does not bear the full cost of that use and the incentive is to overuse the resource. Fugitive resources create special problems for establishing clear property rights.

Second, externalities are another type of market failure common to water resources. Externalities, or third-party effects, occur when a transaction affects someone other than the buyer and seller. Such third-party effects can be important when a water transfer alters the points of diversion or return flow to a stream. To ensure that market transfers improve resource allocation, these third-party effects must be considered. Externalities are also important in many uses of water. For example, virtually all costs of using a stream for waste disposal are borne by downstream water users. Failure to make the polluter pay is a major reason for the poor quality of many water resources.

Third, water resources produce public and private goods. A public good is not marketable. Nonpaying individuals cannot be excluded from enjoying its benefits. The incentive is for users to ride free, which encourages private producers (who are unable to recover their costs in the market) to devote less than the preferred quantity of resources to production of such goods. For instance, allocating water to instream flows may produce beautiful vistas and excellent fishing. Unless a private firm or individual can sell these benefits, however, both will underinvest in instream flows.

Antiquated water law

State law and water institutions provide guidelines for sharing and using water. These laws and institutions evolved in response to changing circumstances. But adjustments to resolve the problems brought on by the increasing economic scarcity of water have been slow in coming. Most laws and institutions are from an era when water essentially was free.

The doctrine of riparian rights, which holds that the owner of land adjacent to a water body has the right to use the water, provided the earliest basis for state laws controlling surface waters. Riparian rights are inseparable from the land. They permit owners to make any "reasonable" use of the water so long as that use does not unduly inconvenience other riparian owners. There is no priority of use because all riparian owners share in reducing use at times when water runs short. Riparian doctrine is still the basis for water law in the relatively water-abundant eastern states.

In the West, where streams are less numerous and their flow is generally lower and less reliable, development required diverting water beyond riparian lands and providing greater assurance of availability. As a result, riparian doctrine was abandoned or at least modified in favor of the doctrine of prior appropriation in all 17 western states. This doctrine establishes the basic principle of "first in time, first in right." In other words, a right is senior to (has priority over) all subsequently acquired rights and is junior to all previously acquired rights. Junior rights bear the full brunt of any water shortages.

Adoption of the appropriation doctrine represented a potentially important step in establishing definable property rights in water. However, other features of western water law have muddied the character of appropriative rights and inhibited the development of markets. In many states these rights have been encumbered by provisions restricting use to specific locations or to beneficial purposes, establishing priorities of use, and granting only usufructuary rights (rights to use the water, not ownership of the water).

Nevertheless, most western states do permit water transfers under certain conditions so long as the rights of third parties are not impaired. This qualification, however, may be difficult to satisfy. The common property nature of water and the externalities associated with most uses make third-party effects ubiquitous. Resolving potential conflicts can result in major delays and high transaction costs, especially if litigation is involved.

State groundwater laws

Early uses of groundwater involved no obvious conflicts among users. Pumping did not exceed the natural recharge of supplies. Absolute ownership became the first doctrine governing groundwater use, and economic considerations were the only constraint on that use.

Groundwater withdrawals have risen rapidly in recent decades, reaching 88 billion gallons a day in 1980, about 23 percent of freshwater withdrawals (*8*). Where withdrawals exceed recharge, a variety of problems may arise—rising water costs, saltwater intrusion into freshwater coastal aquifers, and subsidence of overlying and neighboring lands. And because many aquifers are linked with surface waters, groundwater pumping can jeopardize surface water rights.

Recognition of the need for better groundwater management has led all western states except Texas to abandon the doctrine of absolute groundwater ownership. Most now follow the doctrine of prior appropriation. The basic principle is to grant groundwater permits when the use is beneficial and does not unduly affect prior users.

Application of the doctrine varies widely among states. Few have attempted comprehensive groundwater management. Economic considerations impose the primary constraint on an individual's groundwater use. Groundwater thus tends to be used more efficiently than surface water. Nevertheless, because private costs tend to be less than social costs when use results in depletion or contamination of an aquifer, the incentive is to use these resources faster than society might prefer.

Ground and surface water supplies are often interconnected. About 30 percent of average-year streamflow is supplied by groundwater that emerges as natural springs or other seepage, while seepage from surface waters recharges groundwater supplies (*11*). Consequently, pumping from an aquifer can affect neighboring surface water flows and vice versa. In such instances, conjunctive management of ground and surface water resources is required to achieve efficient water use and to resolve conflicts among users. California provides a few examples of effective conjunctive management of ground and surface waters, but these are exceptions. The general practice is to leave conflicts up to the courts to resolve on an ad hoc basis.

The federal government's role

The federal government also plays an important role in determining how and where water is used. It does so through water projects, reservation of water rights for federal and Indian lands and for navigation, environmental regulations, and negotiations and enforcement of international treaties and interstate compacts.

The Corps of Engineers and the Bureau of Reclamation have been eager to plan, finance, and construct projects to tame rivers and meet virtually all water demands. But these activities have resulted in distortions in the use of both water resources and public funds.

Consider, for example, the activities of the Bureau of Reclamation, an agency established in 1902 to promote settlement of the arid West through irrigation. The initial intent was to recover project costs through user charges. In fact, huge subsidies have gone to irrigators through extended repayment schedules at low interest rates and user charges limited by the ability to pay. Analysis of 18 federal irrigation projects suggests that the discounted value of the subsidies averaged nearly $800 (in 1978 dollars) per acre (*10*). Thus, small farms of 100 acres received subsidies averaging $80,000. Because of lack of enforcement of the 160-acre limit, some larger farms received subsidies valued in the millions of dollars. In view of this largesse it is hardly surprising that political and distributional considerations rather than economic efficiency have dominated the selection of federal water projects. The result: Large sums of public funds have been spent on projects of questionable merit.

Additional economic distortions result from restrictions placed by the Bureau on the use of federally supplied water. Restrictions eliminate opportunities for moving water to higher-value uses and reduce or eliminate incentives to conserve. As a result, isolated areas, where water is viewed and treated essentially as a free resource, have been created within the arid West at enormous public cost. With irrigation accounting for about 90 percent of the West's consumptive use of water and Bureau projects providing water to about 20 percent of the West's irrigated lands, the quantities of water removed by federal projects from the discipline of market forces are enormous. Such profligacy, of course, amplifies the problems and costs of meeting other water needs.

In the previous century, states were granted jurisdiction over all non-navigable water in the public domain. The federal government protected navigable waters under the commerce clause of the Constitution. Since water was not in great demand when most of the lands were withdrawn from the public domain, the federal government neglected to allocate water rights to these lands. The oversight was partially corrected in a 1908 Supreme Court decision. Whenever lands were withdrawn for any purpose (for example, to establish an Indian reservation), the decision said, sufficient water must also be withdrawn from the public domain to accomplish this purpose. These rights, still largely unquantified, exist outside the systems of state law that have allocated most of the surface water in the West.

The Reagan Administration rejects the idea that there are federal water rights that exist independently of state water law. Nevertheless, Indian claims are potentially large in relation to western supplies, and they threaten the legality of rights granted under state law. Uncertainties stemming from unquantified Indian claims discourage investments dependent on water. Uncertainties also pose another obstacle to the creation of well-defined, transferable water rights.

The federal role in water use has increased as a result of the environmental laws and regulations enacted over the past 10 to 15 years. Water provides a convenient way of disposing of wastes. But as noted earlier, once the quantity and toxicity of the wastes starts to threaten the value of receiving waters, waste disposal practices become a cost to society. Because polluters bear only a small and perhaps negligible part of the total costs of their actions, they cannot be expected to alter voluntarily the practices causing the problems.

There are two ways to counter this threat to the quality of the nation's waters. Polluters must be required to pay the costs their actions impose on society, or their actions must be legally restricted and the penalties must be sufficient to ensure a high degree of compliance. In theory, an efficient solution is achieved by requiring polluters to pay the costs associated with their actions. Taxes or fines provide incentives to find less costly alternatives. But there is uncertainty surrounding the costs. No one is sure what the tax should be. In practice, therefore, regulations continue to be the basis of environmental policy.

The technical capability exists to clean up our waters and to treat society's wastes in a manner that does not threaten our water supplies. The costs involved run into the billions of dollars, however; and the political will to commit the needed resources has lagged. The nation's commitment to clean water likely would be stronger if the returns on environmental investments were higher. Better results are possible, but these will require greater reliance on the use of economic incentives and more flexibility in how established standards can be achieved (5).

Some final thoughts

Failure to develop institutions and policies capable of allocating scarce water resources efficiently among competing uses and protecting valued supplies from abuse underlie the nation's water problems. Our standard of living depends on the availability of large quantities of high quality water, yet our confidence that such supplies will be available has waned.

The traditional response to increasing water demands has been to construct more reservoirs or other water supply facilities. But the best sites are in use, and it is becoming costly to add to supply. Moreover, structural solutions often increase offstream water use at the expense of instream uses. Such withdrawals may be justified, but federal subsidies for water projects distort water allocation decisions and are likely to increase scarcity elsewhere.

Nontraditional methods of increasing usable supplies, such as weather modification, use of icebergs, and desalinization, provide no easy answers for meeting growing water demands. With further scientific advances, weather modification may eventually offer an inexpensive source of additional water in some areas. Legal issues are likely to stall its use, however. Economic, technical, and possibly legal obstacles all prevent icebergs from serving as a source of water in arid regions, while economic considerations greatly restrict use of desalinization (*3*).

Solutions to our water problems can no longer ignore the necessity to manage demand. Where supplies are incapable of satisfying demand that is unconstrained by price, incentives must be provided. Consumers, be they farmers, industries, miners, or domestic users, will not conserve until prices force them to do so. Irrigators with rights to inexpensive water that cannot be used on other lands or in alternative activities are unlikely to conserve.

In spite of the market failures associated with water resources, water transfers should be encouraged by establishing well-defined, transferable water rights whenever possible and eliminating restrictions on where and how water can be used. Formal, market-like institutions, such as water banks, might be established to facilitate transfers and identification of and adjustments for third-party effects (*1*). The challenge is to devise systems that protect third-party interests while minimizing transaction costs. When protection is left to the courts, transaction costs are high and act as a deterrent to effective markets.

Market-like solutions are less suitable for dealing with water quality and instream flow issues. But even in these situations, correcting for market failures may be a better policy approach than completely abandoning the market system. As noted, use of economic incentives and greater flexibility in how environmental standards are met should produce better water quality per dollar spent.

Private market decisions tend to underallocate scarce water to instream uses, such as navigation, fish and wildlife, and recreation. While state and federal laws and policies protect some instream uses, the process and the results are unsystematic and erratic. There are no clear objectives or guiding principles. Under the appropriation doctrine of water law employed in the West, water rights are established by withdrawing water from a stream and putting it to beneficial use. Instream uses are not considered beneficial in this sense and do not serve as the basis for privately held water rights. On the other hand, large quantities of water have been reserved for instream uses, such as navigation, without consideration of relative values of the water in alternative uses.

As water values rise, this haphazard approach to instream allocation distorts the allocations even more and adds to concerns about the adequacy of water supplies. Instream water needs should be systematically evaluated and compared with the value of water in offstream uses. This comparison is simplified if water markets exist. Market prices reflect the opportunity costs of reserving or purchasing water for instream flows. Making these costs explicit should help in allocating resources between instream and offstream uses in a way that increases community benefits.

The case for institutional and legal reforms to encourage water markets is based on economic efficiency: Improved efficiency implies a larger social pie. Defenders of the status quo, however, worry about the effects markets might have on the distribution of income and wealth. In principle, greater water efficiency implies that it is possible to make some people better off without making anyone worse off. In practice, greater reliance on markets would make some people worse off.

Irrigators, as the only group for which water costs constitute a significant portion of total expenditures, are usually the focus of concern. But some irrigators would be major beneficiaries of water markets. Farmers own most of the water rights in the West. The value of these rights would increase as constraints on their use are reduced. People who buy their water would face stiffer competition for scarce supplies and, presumably, higher water costs.

Irrigation is a relatively low-value use of water. Water is likely to be transferred from irrigation to other uses under a more market-oriented allocation scheme. Assertions that such transfers would threaten the nation's ability to produce food and fiber competitively have been used to support restrictions on water use. But there is no evidence to support such arguments. The overall effects of water markets on irrigated agricultural production would be small, and they might even be positive. The negative effects of the transfers might be more than offset by the added incentives to conserve water by substituting other productive inputs for increasingly scarce water.

Because irrigation accounts for so much of the consumptive use of water in the West, a relatively small increase in the efficiency of agricultural water use could provide for significant increases in other uses. Policies providing irrigators with low-cost water have been particularly expensive in view of the production surpluses that have characterized agriculture in recent decades. Moreover, these policies are likely to be counterproductive in their longer term impacts on agricultural production. They discourage development and adoption of water conservation measures and hasten the mining of nonrenewable supplies.

Major policy and institutional changes must consider equity or fairness implications. But water does not provide a good lever for achieving such objectives. The interests of the poor are not well served by policies that provide billions of dollars in subsidies for water projects of questionable merit or that reduce the total national product by preventing water from flowing to its highest-value use. Interests in the West are not well served by policies that create and preserve pockets where water is virtually free while adding to the scarcity in the rest of the region. The interests of the nation are not served by lax environmental policies that permit the deterioration of water quality. Nor are the interests of the nation served by ill-conceived regulations that lead to costly, ineffective remedies.

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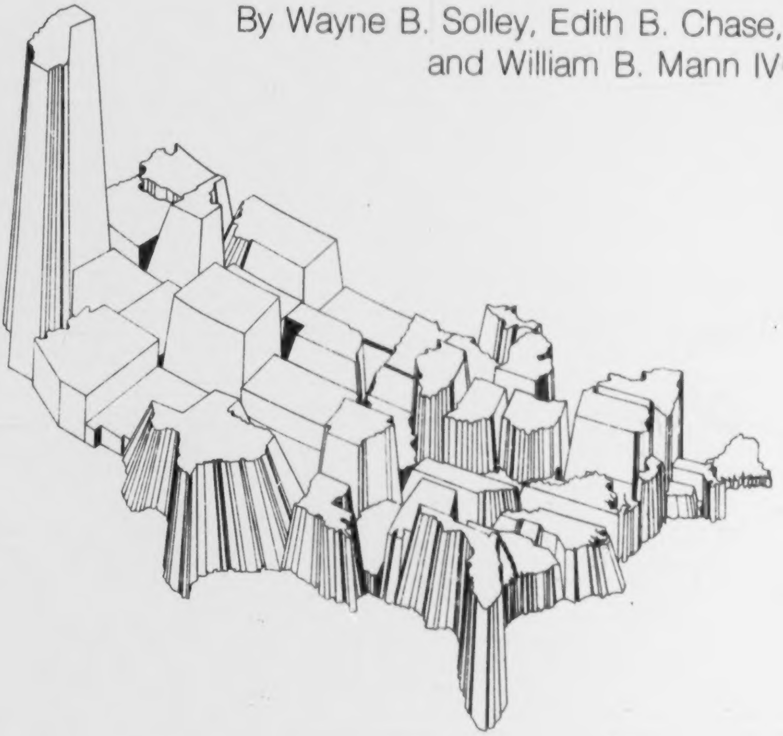
ESTIMATED USE OF WATER IN THE UNITED STATES IN 1980

By Wayne B. Solley, Edith B. Chase,
and William B. Mann IV



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GLOSSARY

Water-use terminology is continuing to expand. The term "water use" as initially used in the U.S. Geological Survey's water-use circulars meant withdrawals of water; in time, the term was redefined to include consumptive use of water as well as withdrawals. With the beginning of the Survey's National Water-Use Information Program (see page 2) the term was further defined as meaning offstream use and instream use.

In an attempt to blend past water-use terminology with the present, this glossary consists of two parts—(A) terms used in this report that are consistent with the terms used in past reports in this circular series, and (B) related terms as used in the National Water-Use Information Program. A chart on page 4 shows the relationship between the categories of water use as used in the circular series and the categories of water use that are being documented by the National Water-Use Information Program.

A. TERMS USED IN THIS REPORT

acre-foot (acre-ft)—the volume of water required to cover 1 acre of land (43,560 square feet) to a depth of 1 foot.

billion gallons per day (bgd)—a rate of flow of water.

commercial water use—water used by motels, hotels, restaurants, office buildings, commercial facilities, and institutions, both civilian and military. The water may be obtained from a public supply or be self supplied. *See also* public supply *and* self-supplied water.

consumptive use—water that is no longer available because it has been evaporated, transpired, incorporated into products or crops, consumed by man or livestock, or otherwise removed from the water environment. Also referred to as water consumption and water consumed.

conveyance loss—water that is lost in transit from a pipe, canal, conduit, or ditch by leakage or evaporation. Generally the water is not available for further use; however, leakage from an irrigation ditch, for example may percolate to a ground-water source and be available for further use.

cooling water—water used for cooling purposes, such as of condensers and nuclear reactors.

domestic water use—water used for normal household purposes, such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens. Also called residential water use. The water may be obtained from a public supply or may be self supplied. *See also* public supply *and* self-supplied water.

evaporation—process by which water is changed from the liquid or solid state to the vapor state. *See also* evapotranspiration *and* transpiration.

evapotranspiration—water lost through evaporation from the soil and surface-water bodies and transpiration from plants. *See also* evaporation *and* transpiration.

fresh water—water that contains less than 1,000 milligrams per liter (mg/L) of dissolved solids; generally, more than 500 mg/L is undesirable for drinking and many industrial uses.

ground water—generally all subsurface water as distinct from surface water; specifically, that part of the subsurface water in the saturated zone (a zone in which all voids, large and small, ideally are filled with water under pressure greater than atmospheric).

hydroelectric power water use—the use of water to drive turbines and generate electric power.

in-channel use—*see* instream use.

industrial water use—water used for thermoelectric power (electric utility generation) and other industrial uses such as steel, chemical and allied products, paper and allied products, mining, and petroleum refining. The water may be obtained from a public supply or may be self-supplied. *See also* public supply *and* self-supplied water.

instream use—water use taking place within the stream channel for purposes such as hydroelectric power generation, navigation, water-quality improvement, fish propagation, and recreation. Sometimes called nonwithdrawal use or in-channel use.

irrigation water use—artifical application of water on lands to assist in the growing of crops and pastures or maintaining recreational lands such as parks and golf courses.

livestock water use—water used by livestock. Livestock as used here includes cattle, sheep, goats, hogs, and poultry. Also included are animal specialities such as horses, rabbits, bees, pets, fur-bearing animals in captivity, and fish in captivity. *See also* rural water use.

million gallons per day (mgd)—a rate of flow of water.

nonwithdrawal use—*see* instream use.

off-channel use—*see* offstream use.

offstream use—water withdrawn or diverted from a ground- or surface-water source for public supply, industry, irrigation, and rural uses. Sometimes called off-channel use or withdrawal use.

per capita use—the average amount of water used per person per day.

public supply—water withdrawn for all uses by public and private water suppliers and delivered to users that do not supply their own water. Water suppliers provide water for a variety of uses such as domestic, commercial, industrial, and public water use. *See also* commercial water use, domestic water use, industrial water use, *and* public water use.

public water use—water supplied from a public supply and used for firefighting, street washing, and municipal parks and swimming pools. *See also* public supply.

reclaimed sewage—treatment plant effluent that has been diverted or intercepted for use before it reaches a natural waterway or aquifer.

recycled water—water that is used more than one time.

residential water use—*see* domestic water use.

reuse—*see* recycled water.

rural water use—water used in suburban or farm areas for domestic and livestock needs. The water generally is self-supplied, and includes domestic use, drinking water for livestock, and other uses such as dairy sanitation, evaporation from stock-watering ponds, and cleaning and waste disposal. *See also* domestic water use, livestock water use, self-supplied water, *and* agricultural nonirrigation water use (part B of glossary).

saline water—water that contains more than 1,000 milligrams per liter (mg/L) of dissolved solids.

self-supplied industrial use—*see* industrial water use *and* self-supplied water.

self-supplied water—water withdrawn from a surface- or ground-water source by a user and not obtained from a public supply. *See* also industrial water use *and* rural water use.

surface water—an open body of water such as a stream or a lake.

thermoelectric power—electrical power generated using fossil-fuel (coal, oil, or natural gas), geothermal, or nuclear energy.

transpiration—process by which water absorbed by plants, usually through the roots, is evaporated into the atmosphere from the plant surface. *See also* evaporation *and* evapotranspiration.

water consumed—*see* consumptive use.

water consumption—*see* consumptive use.

water-resources region—natural drainage basin or hydrologic area that contains either the drainage area of a major river or the combined drainage areas of a series of rivers; there are 21 regions of which 18 are in the conterminous United States, and one each in Alaska, Hawaii, and the Caribbean. (See map on inside of front cover.)

water use—*see* offstream use *and* instream use.

water utility—*see* public supply.

withdrawal—water removed from the ground or diverted from a surface-water source for use. *See also* offstream use.

withdrawal use—*see* offstream use.

B. RELATED TERMS

agricultural nonirrigation water use—water used for stock watering, feed lots, dairy operations, and other on-farm needs. Does not include rural domestic water use nor irrigation water use. *See also* livestock water use (part A of glossary).

aquifer—a geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

delivery/release—the amount of water delivered to the point of use and the amount released after use; the difference between these amounts can be the consumptive use. *See also* consumptive use (part A of glossary).

injection water—water that is injected into an aquifer or an unsaturated porous formation for storage, disposal, or displacement.

irrigation return flow—the part of artifically applied water that is not consumed by evapotranspiration and that migrates to an aquifer or surface-water body.

mining water use—water used in the extraction of minerals occurring naturally: solids, such as coal and ores; liquids, such as crude petroleum; and gases, such as natural gas. Also includes quarrying, well operation, milling (crushing, screening, washing, flotation, etc.) and other preparation customarily done at the mine site, or as part of a mining activity. Does not include the processing of raw materials, such as smelting ores, refining petroleum, and slurry pipeline operations. *See also* industrial water use (part A of glossary).

return flow—the amount of water that reaches a ground- or surface-water source after release from the point of use and thus becomes available for further use.

standard industrial classification codes (SIC)—four digit codes established by the U.S. Bureau of Census and used in the classification of establishments by type of activity in which they are engaged.

CONVERSION FACTORS

Multiply	*By*	*To obtain*
	AREA	
acres	43,560	square feet (ft^2)
	4,047	square meters (m^2)
	0.001562	square miles (m^2)
	FLOW	
billion gallons per day (bgd)	1,000	million gallons per day
	1,121	thousand acre-feet per year
	1.547	thousand cubic feet per second
	694.4	thousand gallons per minute
	3.785	million cubic meters per day
million gallons per day (mgd)	0.001	billion gallons per day
	1.121	thousand acre-feet per year
	0.001547	thousand cubic feet per second
	0.6944	thousand gallons per minute
	0.003785	million cubic meters per day
thousand acre-feet per year	0.0008921	billion gallons per day
	0.8921	million gallons per day
	0.001380	thousand cubic feet per second
	0.6195	thousand gallons per minute
	0.003377	million cubic meters per day

SELECTED WATER RELATIONSHIPS (approximations)

1 gallon = 8.34 pounds
1 million gallons = 3.07 acre-feet
1 cubic foot = 62.4 pounds
= 7.48 gallons

1 acre-foot = 325,851 gallons
(1 acre covered by 1 foot of water) = 43,560 cubic feet

1 cubic mile = 1.1 trillion gallons
= 3,379,200 acre-feet

1 inch of rain = 17.4 million gallons per square mile
= 27,200 gallons per acre
= 100 tons per acre

ESTIMATED USE OF WATER IN THE UNITED STATES IN 1980

By Wayne B. Solley, Edith B. Chase,
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ABSTRACT

Water use in the United States in 1980 was estimated to be an average of 450 bgd (billion gallons per day) of fresh and saline water for offstream uses—an 8-percent increase from the 1975 estimate and a 22-percent increase from the 1970 estimate. Average per capita use for all offstream uses was 2,000 gpd (gallons per day) of fresh and saline water, and 1,600 gpd of fresh water; this represents a slight increase since 1975.

Offstream uses include (1) public supply (domestic, public, commercial, and industrial uses), (2) rural (domestic and livestock uses), (3) irrigation, and (4) self-supplied industrial uses (including thermoelectric power). From 1975 to 1980, public-supply use increased 15 percent to 34 bgd, rural use increased 14 percent to 5.6 bgd, irrigation use increased 7 percent to 150 bgd, and self-supplied industrial use increased 8 percent to 260 bgd. Within the industrial category, thermoelectric power generation increased 9 percent to 210 bgd, whereas other self-supplied industrial uses remained approximately constant at 45 bgd.

Total fresh water consumed—that part of water withdrawn that is no longer available for subsequent use—by these offstream uses increased 7 percent to 100 bgd, with irrigation accounting for the largest part of water consumed, estimated at 83 bgd.

Estimates of withdrawals by source indicate that from 1975 to 1980, total groundwater withdrawals increased 7 percent to 89 bgd, and total surface-water withdrawals increased 9 percent to 360 bgd. Total saline-water withdrawals increased by about 2 bgd to 72 bgd, of which 71 bgd was saline surface water. Reclaimed sewage amounted to about 0.5 bgd in 1980, an 11-percent decrease from 1975.

A comparison of withdrawals by States indicates that California withdrew the most water for offstream use, 54 bgd, more than double the amounts withdrawn by Florida and Texas, the next largest users. A similar comparison by water-resources regions indicates that the California and Mid-Atlantic regions accounted for nearly one quarter of the total water withdrawn in the United States. Total withdrawals for offstream use in the eastern water-resources regions, which include the Mississippi and Souris Rivers, accounted for 55 percent of the Nation's total withdrawals. Fresh-water consumptive use in the East was 8 percent of the total eastern withdrawals and accounted for only 19 percent of the national total consumptive use of 100 bgd. By comparison, consumptive use in the western water-resources regions accounted for 41 percent of the withdrawals in the West. The higher consumptive use in the West can be attributed to the fact that 91 percent of the total water withdrawn for irrigation occurred in the West and irrigation accounts for the largest part of water consumed.

Water used for hydroelectric power generation, an instream use, remained unchanged from 1975 at 3,300 bgd. This is in contrast to the increasing trend from 1950 to 1975.

Although 1980 estimates of water use were higher than the 1975 estimates for all offstream categories, trends established during the periods 1970 to 1975 and 1975 to 1980 indicate a general slackening in the rate of increase of total withdrawals in comparison to the period 1965 to 1970.

INTRODUCTION

Purpose and Scope

Estimated amounts of water withdrawn from ground- and surface-water sources for use in the United States during 1980 are presented in this report. The U.S. Geological Survey has compiled similar national-estimate summaries every 5 years since 1950 (MacKichan, 1951, 1957; MacKichan and Kammerer, 1961, Murray, 1968; and Murray and Reeves, 1972, 1977). Quantitative assessments derived from this series of reports can be used to appraise present use and to plan for future use of the Nation's water resources.

Two major subdivisions of water use are offstream use and instream use. In the section "Offstream Use," four categories of water use are discussed: public supply, which includes water delivered to domestic, public, commercial, and industrial users from public supply systems; rural use, which includes self-supplied domestic and livestock use; irrigation use; and self-supplied industrial use. In the section "Instream Use," only hydroelectric power is discussed; other instream uses, such as navigation and recreation, are beyond the scope of this report.

The water-use categories used in this report are the same as those used in the previous U.S. Geological Survey water-use circulars. Thus, the user of these reports can aggregate or disaggregate the information to obtain comparative figures for each category of water use. Although the categories of water use are the same, the organization and presentation of the data differ from the previous reports. For each category of water use, there is a discussion of the 1980 use and a comparison of those data with the 1975 data. The text is supplemented with tables and illustrations showing data for each State, Puerto Rico, the Virgin Islands, and the District of Columbia and for each of the 21 water-resources regions. (See map on inside of front cover for boundaries of the water-resources regions and the relationship of the regions to the States.) At the end of the report is a summary section of 1980 water use by categories and source, and a section on trends in water use for the period 1950–80.

National Water-Use Information Program

Numerous reports on the subject of water use have been published in the past 30 years. Generally these reports pertain either to a specific category of use or cover a particular geographical area for which data on the various categories of water use are given. Although the U.S. Geological Survey has published national estimates of water use in the United States since 1950 at 5-year intervals, these estimates were derived from a variety of sources having a wide range of accuracy.

In 1977, the Congress of the United States recognized the need for uniform, current, and reliable information on water use and directed the U.S. Geological Survey to establish a National Water-Use Information Program to complement the Survey's data on the availability and quality of the Nation's water resources.

Thus, the National Water-Use Information Program became part of the U.S. Geological Survey's Federal-State Cooperative Program (Mann and others, 1982). As of 1981, when this report was being compiled, 47 States were participating in the program at various levels of involvement.

As stated by Viessman and DeMoncada (1980, p.1) "There are many inconsistencies in the ways in which data are reported. The major State and Federal agencies involved in reporting current water use patterns and in projecting future water use are not always in agreement on definitions of terms, units of measurement, or methods of estimating water use. This makes it difficult, at times, to reconcile State and Federal figures and to use efficiently the information that is available." The National Water-Use Information Program is designed to overcome these problems and to be the source for accurate, consistent, timely, and accessible water-use information. The goals of the program are to collect and compile reliable water-use information, to develop and refine computerized water-use information systems at both the State and national levels, to devise new methods and techniques to improve the collection and analysis of water-use information, and to disseminate the information in ways that adapt to the needs of a variety of users.

The National Water-Use Information Program helped increase the accuracy of the information collected and compiled for this report by providing funds to support more comprehensive field data collection and more detailed evaluations of existing water-use data. As more State water-use information systems are developed and refined, the timeliness and accuracy of water-use data at both State and national levels will continue to improve.

Terminology

The terms and units used in this report are similar to those used in previous reports in this series. A few changes have been made, and these changes are explained below. Significant terms also are defined in the glossary.

The term "off-channel use" previously was used to represent all water withdrawn or diverted from a ground- or surface-water source, including the water used for hydroelectric power generation. In this report, the term "offstream use" replaces the term "off-channel use." Note, however, as explained below, that water for hydroelectric power generation is now discussed as an instream use.

"In-channel use" has been replaced by the term "instream use," which is defined as water use taking place within the stream channel for purposes such as hydroelectric power generation, navigation, water-quality improvement, fish propagation, and recreation. The term "nonwithdrawal use" frequently has been used interchangeably with instream use. In previous reports of this series, water used to generate hydroelectric power was included with "off-channel" or "withdrawal" use because the water is passed through the power plant and thus was considered a "withdrawal" of water. In this report, hydroelectric power generation is discussed specifically as an instream use.

The terms "fresh water," "saline water," and "reclaimed sewage," as types of water used in various categories, are defined in the glossary. Ground water and surface water, as sources of water, also are defined in the glossary.

The five categories of water use discussed in this report are the same as those discussed in the previous reports in this series. These categories have been subdivided and, in some instances, reclassified for use in the National Water-Use Information Program. The chart below is designed to be used as a cross reference to the two classification schemes. For example, if the reader looks at the category "rural use" as used to date in the water-use circular series, the X's show that nonirrigation and domestic are the categories used in the National Water-Use Information Program. Conversely, if the reader looks at the category "nonirrigation" as used in the National Water-Use Information Program, the X's show that rural use is the category that has been used in the water-use circular series.

Relationship of categories of water use as identified in the —					
National Water-Use Information Program	Water-use circular series (1950–1980)				
	Public supply	Rural	Irrigation	Self-supplied industrial	Hydroelectric power
As of 1980					
Agriculture:					
Nonirrigation	...	X	...	...	...
Irrigation	...	...	X	...	...
Commercial	X	...	...	...	...
Domestic	X	X	...	...	...
Industrial	X	...	...	X	...
Mining	...	...	...	X	...
Power:					
Fossil fuel	...	...	...	X	...
Geothermal	...	...	...	X	...
Hydroelectric	...	...	...	...	X
Nuclear	...	...	...	X	...
Public:					
Water supply	X	...	...	...	...
Sewage treatment	...	...	...	...	...
Planned for future					
Aquaculture	...	...	...	X	...
Navigation	...	...	...	...	...
Preservation	...	...	...	...	...
Quality improvement	...	...	...	...	...
Recreation	...	...	...	...	...
Treaties	...	...	...	...	...

Methodology

The U.S. Geological Survey's District Offices, in cooperation with State and local agencies, compiled water-use estimates based on information for 222 water-resources subregions (for explanation of subregions see References Cited, U.S. Geological Survey, 1980). These estimates were submitted to the

Survey Headquarters in Reston, Va. The information was then aggregated by States (including Puerto Rico, the Virgin Islands, and the District of Columbia) and by the 21 water-resources regions for the five categories of water use. Accuracy of the data varies and is discussed for each category of water use in subsequent parts of this report.

Numerical data in this report were derived from several sources, and each type of data and the rounding method used is explained below. The reader is cautioned that all numbers were rounded independently; thus, the individual rounded numbers may not add to the totals.

Water-use numerical data are the average daily quantities used, as derived from annual-use data, and generally are rounded to two significant figures. Most tables in this report show these data in million gallons per day (mgd). For ease of reference, data in the text and illustrations are given in billion gallons per day (bgd). Selected tables also show per-capita-use data in gallons per day (gpd) rounded to three significant figures, and irrigation-use data in thousand-acre feet per year.

Population data, which are from the U.S. Bureau of Census advance survey of 1980 (U.S. Bureau of the Census, 1982), generally are shown to the nearest thousand. Data on population served by public supply were compiled in cooperation with State and local agencies and these data are rounded to three significant figures. The number of people served by self-supplied systems was determined by subtracting the number of people served by public supply from the total population.

The percentage changes discussed in the text are calculated from the unrounded "raw" numbers rather than from the rounded numbers described above.

A conversion table is given at the end of the glossary to assist those readers who may wish to convert the data to other units of measurement.

Acknowledgments

The authors wish to acknowledge the assistance provided by the many State and local agencies that cooperated with the U.S. Geological Survey's District Offices in the compilation of data for this report. Many of the States have published reports on water use as part of their participation in the National Water-Use Information Program, and a selected list of these publications is given at the end of this report.

The authors also wish to thank Dr. Warren Viessman, Jr., Congressional Research Service, The Library of Congress, for his critical review of this report.

Special acknowledgment is given to C. Richard Murray, recently retired from the U.S. Geological Survey, for his dedicated efforts in compiling data for this report and for his outstanding contributions as primary or sole author of the three previous reports of this circular series.

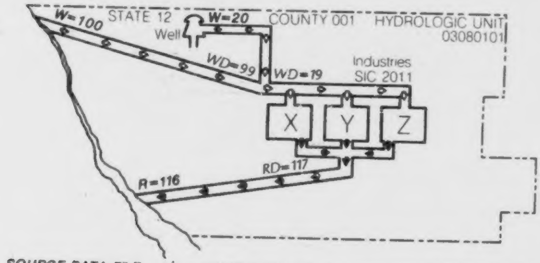
WATER USE

Water use in this report is considered as offstream use and instream use. The difference between these two types of use is explained below.

Offstream use.—Offstream use is a water use that depends on water being withdrawn or diverted from a ground- or surface-water source. To determine the amount of water used, three factors are involved.

1. Withdrawals—the amount of water withdrawn or diverted from a ground- or surface-water source.
2. Delivery/release—the amount of water delivered at the point of use and the amount released after use. The difference between these volumes will in some instances be the consumptive use, the amount of water that is no longer available for subsequent use.
3. Return flow—the amount of water that reaches a ground- or surface-water source after release from the point of use and becomes available for further use.

The illustration below explains how these factors are aggregated for three industries (x, y, z) in the same SIC class.



SOURCE DATA FILE + *USAGE DATA FILE* = WATER-USE INFORMATION

	mgd
W- Withdrawn from:	
Surface water	*100*
Ground water	*20*
R- Returned to Surface water	*116*

	mgd
WD- Delivered to industries:	
Surface water	99
Ground water	19
RD- Released from industries	*117*

	mgd
Withdrawals	*120*
Usage	*118*
Return flow	*116*
Consumptive use	1
Conveyance losses	3

Withdrawals (W), Usage (WD), Return flow (R), Consumptive use (WD—RD), Conveyance losses [(W—WD)+(RD—R)]

HYPOTHETICAL AGGREGATED WATER-USE INFORMATION FOR INDUSTRIES X,Y, and Z DERIVED FROM SOURCE AND USAGE DATA FILES

In this report, withdrawal data and estimates of consumptive use are given for four categories of offstream use: public supply (water delivered to domestic, commercial and industrial users), rural use (self-supplied domestic and livestock use), irrigation use, and self-supplied industrial use. Data on delivery/releases and return flows were not adequate for detailed discussions; however, generalized return-flow information is presented graphically for each category of use.

It should be noted that each category of use has characteristically different effects on the usability or reuse potential of return flows. Reuse potential is a measure of the quality and quantity of water available for subsequent use. For example, irrigation return flow may be contaminated by pesticides and fertilizers, and, because of the high consumptive use in irrigation, the mineral content of the return flow often is increased substantially. Consequently, irrigation return flow frequently has little reuse potential. This reuse potential is a significant contrast to that of water discharged from thermoelectric plants, where the principal change in the water is an increase in temperature, and the return flow has maximum potential for further use. The National Water-Use Information Program is now documenting return flows, and future reports will contain such data. Future plans also include obtaining information on water-quality changes associated with the various uses of water.

Instream use.--Instream use is a water use not dependent on withdrawal or diversion from ground- or surface-water sources, and it usually is classified as flow uses or onsite uses. Examples of flow uses, which depend on water running freely in a channel, are hydroelectric power generation, fresh-water sweetening of saline estuaries, maintenance of minimum streamflow to support fish propagation, and the disposition and dilution of waste water. Onsite uses may occur when water is used directly in a water course, lake, reservoir, or other body of water—an example is evaporation from a lake or reservoir associated with hydroelectric power generation.

Quantitative estimates for most instream uses are difficult to make. However, because such uses reflect the level of competition with offstream uses and affect the quantity and quality of water resources for all uses, effective water-resources management requires that methods and procedures be devised to enable instream uses to be quantitatively determined.

The only instream use discussed in this report is hydroelectric power generation. Unlike other instream uses, the water used for hydroelectric power generation is a measurable quantity, because the water is passed through the plant and can be documented. Consumptive use in hydroelectric power generation generally is negligible and is not discussed.

Public Supply

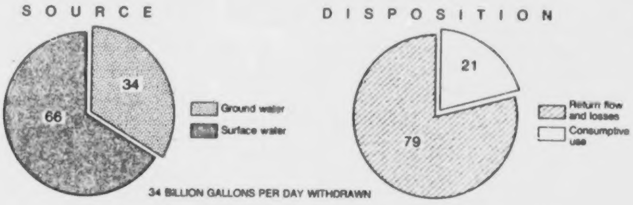
Public supply refers to water withdrawn by public and private water suppliers and delivered to a variety of users for domestic or household use, public use, industrial use, and commercial use. Public suppliers served about 186 million people in 1980, about 81 percent of the total population, a slight increase in percentage since 1975. Domestic use includes such activities as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens. Public use includes water for firefighting, street washing, and municipal parks and swimming pools. Many industrial and commercial establishments use public supplies, especially where the volume of water required is small and the quality of water must be high. However, some industries that require large amounts of water also use public supply for principal or auxiliary water. Among commercial users are hotels, restaurants, laundry services, office facilities, and institutions, both civilian and military. Data on population served by public supply and public-supply withdrawals and deliveries usually are reliable because local government agencies generally maintain relatively complete files.

Total water withdrawn for public supply in 1980 was estimated as 34 bgd, or an average of 183 gpd for each individual served (see tables 1 and 2). This amount represents a 15-percent increase from 1975 when 29 bgd of water was withdrawn for public supply or a per capita use of 168 gpd. (See "Methodology" section for how percentages were derived.) Part of this increase is due to the fact that nearly 2 bgd of water erroneously identified in previous reports as self-supplied industrial withdrawals is now included in the public-supply category. Another factor in the increase in this category is a 6-percent increase from 1975 in population served by public supplies along with higher per capita use. Combined daily average for domestic and public uses accounted for almost two-thirds of the public-supply withdrawals and was estimated at 22 bgd, or an average of 120 gpd for each individual served, compared to a per capita use of 117 gpd in 1975. Included in the 22 bgd is water lost in the distribution system. Industrial and commercial users received the other third of the public-supply withdrawals, about the same distribution as in 1975.

Water consumed by public-supply users increased 6 percent to 7.1 bgd in 1980, and accounted for about 21 percent of the public-supply withdrawals, approximately the same proportion as in 1965, 1970, and 1975. The larger cities were supplied principally by surface-water sources, which furnished about two-thirds of the public-supplied water.

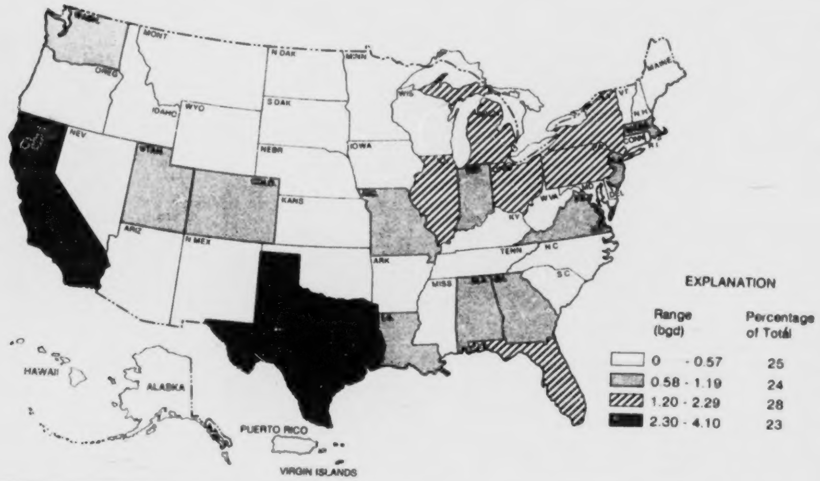
California, New York, and Texas, the three most populated States, withdrew the most water for public supplies, and accounted for about 30 percent of the Nation's total withdrawal by public suppliers. Per capita domestic use from public supplies averaged 100 gpd for the Eastern States and 150 gpd for the western States (see table 13). The two most populated water-resources regions, California and Mid-Atlantic, withdrew the most water for public supplies, and accounted for about 28 percent of the total withdrawal by public suppliers.

The range in public-supply fresh-water withdrawals by States and water-resources regions is shown in figure 1. Public-supply water-use data by States are given in table 1, and the same data by water-resources regions are given in table 2. The source of and disposition of withdrawals for public supply are shown in the chart below.



WATER WITHDRAWN FOR PUBLIC SUPPLY BY SOURCE AND DISPOSITION, 1980, IN PERCENT.

A. States



B. Water-resources regions

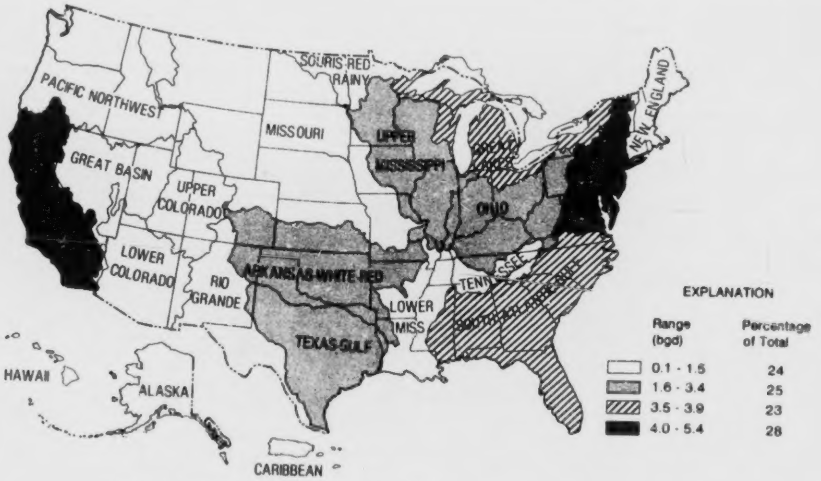


Figure 1. Public supply fresh-water withdrawals, by States and water-resources regions, 1980.

Table 1.—*PUBLIC SUPPLIED FRESH-WATER USE, BY STATES, 1980*

[Water-use data generally are rounded to two significant figures, population data and per capita data are rounded to three significant figures; figures may not add to totals because of independent rounding. mgd = million gallons per day; gpd = gallons per day]

STATE	POPULATION SERVED, in thousands			PER CAPITA USE, in gpd	WATER WITHDRAWALS, in mgd			WATER DELIVERED, BY TYPE OF USE, in mgd		CONSUMPTIVE USE, in mgd
	Source				Source					
	Ground water	Surface water	Total		Ground water	Surface water	Total	Industrial and commercial	Domestic and public[1]	
Alabama	1200	1740	2950	210	160	460	620	230	390	44
Alaska	172	113	286	187	23	30	53	14	40	33
Arizona	1490	945	2440	230	300	260	560	180	380	340
Arkansas	880	816	1700	155	110	150	260	77	190	64
California	9580	12700	22300	183	1900	2200	4100	800	3300	1700
Colorado	320	2220	2540	233	48	540	590	80	510	160
Connecticut	521	1980	2500	143	55	300	360	140	220	89
Delaware	254	240	494	158	30	48	78	8.6	69	0
D.C.	0	638	638	326	0	210	210	62	150	21
Florida	6800	991	7790	175	1200	180	1400	240	1100	330
Georgia	1320	2860	4180	185	230	540	770	360	410	180
Hawaii	914	51	965	207	180	15	200	64	140	60
Idaho	592	117	709	231	150	16	160	15	150	51
Illinois	4050	6690	10700	170	480	1300	1800	1000	790	18
Indiana	1920	1430	3350	172	300	280	580	270	300	79
Iowa	1600	528	2120	146	230	84	310	92	220	47
Kansas	903	832	1740	168	140	150	290	71	220	83
Kentucky	375	2080	2450	145	47	300	350	72	280	23
Louisiana	1850	1310	3160	192	270	340	610	91	510	350
Maine	101	372	473	221	20	85	100	34	70	10
Maryland	417	3040	3460	141	48	440	490	87	400	24
Massachusetts	1550	3850	5400	149	190	610	800	240	560	41
Michigan	1310	5280	6590	190	220	1000	1300	670	580	100
Minnesota	1910	1010	2920	150	230	210	440	130	300	44
Mississippi	1800	182	1980	147	250	42	290	80	210	100
Missouri	1520	3160	4690	156	160	570	730	300	440	150
Montana	184	339	524	273	50	93	140	54	89	53
Nebraska	961	276	1240	213	210	56	260	69	190	53
Nevada	329	392	721	322	93	140	230	80	150	69
New Hampshire	392	366	758	117	43	46	89	25	64	4.9
New Jersey	3420	3940	7360	145	450	620	1100	250	820	200
New Mexico	798	82	880	240	190	21	210	12	200	99
New York	3510	12100	15700	143	350	1900	2200	950	1300	380
North Carolina	474	2640	3110	184	70	500	570	230	340	110
North Dakota	258	247	505	116	26	33	59	5.6	53	34
Ohio	2950	6040	8990	160	380	1100	1400	630	800	180
Oklahoma	662	1670	2330	130	86	220	300	100	200	120
Oregon	344	851	1200	193	66	160	230	90	140	47
Pennsylvania	2180	6620	8800	172	240	1300	1500	350	1200	160
Rhode Island	142	723	864	147	19	110	130	50	77	6.3
South Carolina	541	1780	2320	152	78	270	350	130	230	53
South Dakota	321	134	455	167	52	24	76	21	55	15
Tennessee	1450	2270	3720	137	200	310	510	140	370	55
Texas	5030	6360	11400	335	930	2900	3800	2000	1800	640
Utah	662	634	1300	575	380	370	750	140	610	300
Vermont	113	207	320	149	17	31	48	15	33	5.8
Virginia	707	3160	3860	154	120	480	600	150	450	32
Washington	2100	1200	3300	246	300	510	810	370	440	170
West Virginia	411	921	1330	134	49	130	180	61	120	0.6
Wisconsin	1620	1420	3040	188	290	280	570	250	320	37
Wyoming	122	200	322	256	27	55	82	15	68	48
Puerto Rico	669	2530	3200	109	73	280	350	88	260	74
Virgin Islands	32	32	64	63	2.0	2.0	4.0	0.2	3.8	0.8
Total	73,700	112,000	186,000	183	12,000	22,000	34,000	12,000	22,000	7,100

[1] Includes losses in the distribution system.

Table 2.—*PUBLIC SUPPLIED FRESH-WATER USE, BY REGIONS, 1980*

[Water-use data generally are rounded to two significant figures, population data and per capita data are rounded to three significant figures; figures may not add to totals because of independent rounding. mgd = million gallons per day; gpd = gallons per day]

WATER-RESOURCES REGION	POPULATION SERVED, in thousands			PER CAPITA USE, in gpd	WATER WITHDRAWALS, in mgd			WATER DELIVERED, BY TYPE OF USE, in mgd		CONSUMPTIVE USE, in mgd
	Source		Total		Source		Total			
	Ground water	Surface water			Ground water	Surface water		Industrial and commercial	Domestic and public[1]	
New England	2730	7310	10000	148	330	1200	1500	490	1000	150
Mid-Atlantic	9440	24600	34100	159	1100	4300	5400	1500	3900	710
South Atlantic-Gulf	11400	10000	21400	177	1900	1900	3800	1200	2600	760
Great Lakes	2970	18600	21500	182	440	3500	3900	2100	1800	310
Ohio	5600	9710	15300	144	730	1500	2200	790	1400	240
Tennessee	727	1950	2680	153	89	320	410	95	310	44
Upper Mississippi	8330	4240	12600	155	1100	820	1900	860	1100	180
Lower Mississippi	4170	1170	5330	172	610	310	920	210	710	400
Souris-Red-Rainy	253	241	494	116	27	30	57	11	46	22
Missouri Basin	3360	4730	8090	171	530	850	1400	320	1100	360
Arkansas-White-Red	2280	3810	6090	255	320	1200	1600	790	760	310
Texas-Gulf	4330	5810	10100	298	800	2200	3000	1400	1600	350
Rio Grande	1100	268	1370	232	240	74	320	21	300	140
Upper Colorado	91	266	357	347	23	100	120	18	110	61
Lower Colorado	1710	1200	2910	248	370	350	720	230	490	390
Great Basin	800	769	1570	514	400	410	810	160	650	310
Pacific Northwest	3050	2260	5320	237	530	730	1300	560	770	290
California	9610	12700	22300	183	1900	2200	4100	800	3300	2700
Alaska	172	113	286	187	23	30	53	14	40	33
Hawaii	914	51	965	207	180	15	200	64	140	60
Caribbean	701	2560	3260	108	75	280	350	88	270	75
Total	73,700	112,000	186,000	183	12,000	22,000	34,000	12,000	22,000	7,100

[1] Includes losses in the distribution system.

Rural Use

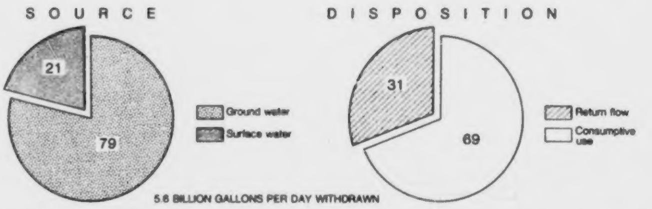
Water for rural use includes self-supplied domestic use, drinking water for livestock, and other uses such as dairy sanitation, evaporation from stock-watering ponds, and cleaning and waste disposal. The number of people served by self-supplied systems was determined by subtracting the total number of people served by public-supply systems from the total population, as derived from the U.S. Bureau of Census advance population data for 1980. The difference between these totals showed that 44 million people were served by their own water-supply systems in 1980, compared to 41 million people in 1975. Rural self-supplied systems rarely are metered and few "hard" data exist. Therefore, water for rural use can only be estimated.

The quantity of fresh water withdrawn for rural domestic and livestock use in 1980 was 5.6 bgd, a 14-percent increase from 1975. Rural domestic withdrawals were 3.4 bgd, a 23-percent increase from 1975. This large increase is the result of the increased population being served by self-supplied systems and an increase in the per capita use, which was about 79 gpd compared to about 68 gpd in 1975. The increase in per capita use reflects the application of more realistic estimating techniques, which also indicate that previous estimates were probably too low. The quantity of water used by livestock increased slightly from 2.1 bgd in 1975 to nearly 2.2 bgd in 1980.

The consumptive use of fresh water for rural domestic use and livestock use in 1980 was about 2.0 bgd and 1.9 bgd, or 57 and 88 percent of withdrawals, respectively. Total consumptive use was 69 percent of total rural withdrawals. Only about 5 percent of the rural domestic water was surface water, but some 45 percent of the water used for livestock was surface water.

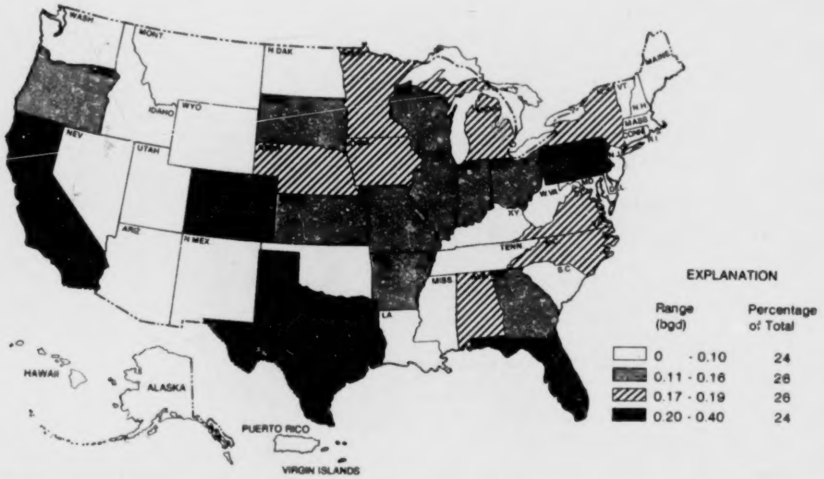
Rural domestic and livestock water use is fairly evenly distributed among the States with Texas and Florida the major users accounting for 7 percent and 6 percent, respectively. The South Atlantic-Gulf water-resources region withdrew the most water for total rural use, and it also experienced the largest volume increase in rural domestic withdrawals. The Missouri Basin region withdrew the most water for rural livestock use and accounted for about 18 percent of the total withdrawals for livestock use.

The range in rural fresh-water withdrawals by States and water-resources regions is shown in figure 2. Rural water-use data by States are given in table 3, and the same data by water-resources regions are given in table 4. The source of and disposition of withdrawals for rural use are shown in the chart below.



WATER WITHDRAWN FOR RURAL DOMESTIC AND LIVESTOCK USE BY SOURCE AND DISPOSITION, 1980, IN PERCENT.

A. States



B. Water-resources regions

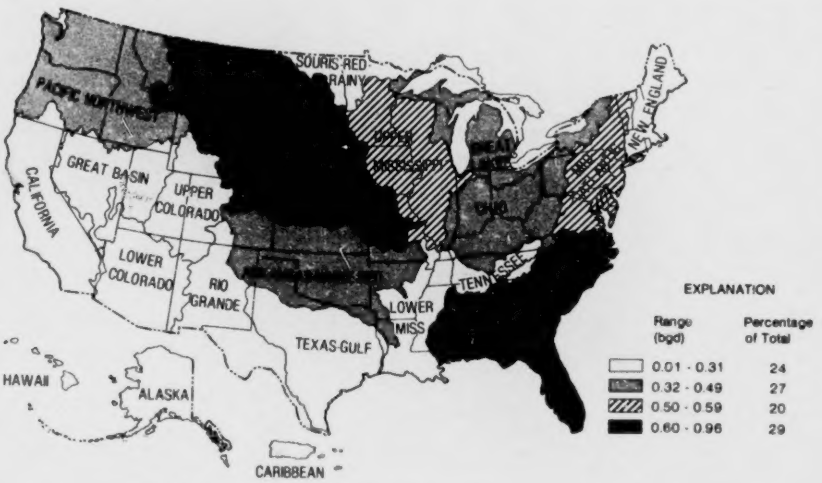


Figure 2. Rural fresh-water withdrawals, by States and water-resources regions, 1980.

Table 3.—*RURAL FRESH-WATER USE, BY STATES, IN MILLION GALLONS PER DAY, 1980*

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

STATE	DOMESTIC USE				LIVESTOCK USE				TOTAL DOMESTIC AND LIVESTOCK USE			
	Withdrawals			Consumptive use	Withdrawals			Consumptive use	Withdrawals			Consumptive use
	By source		Total		By source		Total		By source		Total	
	Ground water	Surface water			Ground water	Surface water			Ground water	Surface water		
Alabama	100	0	100	100	25	63	88	88	130	63	190	190
Alaska	11	0.1	11	0.1	0	0.1	0.2	0.2	11	0.3	11	0.3
Arizona	32	0	32	24	9.8	1.8	12	8.1	42	1.8	43	32
Arkansas	57	0	57	51	22	39	61	61	78	39	120	110
California	130	9.5	140	82	36	51	87	46	160	60	220	130
Colorado	35	62	98	24	19	86	110	35	54	150	200	59
Connecticut	53	0	53	32	0.4	1.8	2.2	2.2	54	1.8	56	34
Delaware	25	0	25	0	2.0	0	2.0	2.0	27	0	27	2.0
D.C.	0	0	0	0	0	0	0	0	0	0	0	0
Florida	250	0.1	250	42	39	20	59	59	290	20	310	100
Georgia	140	0	140	85	17	11	28	28	150	11	160	110
Hawaii	3.5	0.4	3.9	3.4	5.3	0.2	5.5	4.8	8.8	0.6	9.4	8.2
Idaho	44	2.0	46	11	9.3	13	22	19	53	15	68	30
Illinois	79	3.6	82	58	49	16	65	65	130	20	150	120
Indiana	110	5.6	120	120	24	19	42	42	130	24	160	160
Iowa	55	0.2	55	22	100	25	130	130	160	25	180	150
Kansas	58	4.3	63	59	35	46	81	79	93	50	140	140
Kentucky	54	6.3	61	48	1.9	37	39	39	56	43	99	87
Louisiana	54	0	54	39	12	5.2	18	18	67	5.2	72	57
Maine	26	0.5	26	26	1.0	0.7	1.7	1.7	27	1.2	28	28
Maryland	49	0	49	32	10	0.5	11	11	59	0.5	60	43
Massachusetts	32	0	32	3.9	0.7	0.5	1.2	1.2	32	0.5	33	5.1
Michigan	160	0	160	27	17	5.0	22	19	180	5.0	180	46
Minnesota	120	0	120	120	58	10	68	68	180	10	190	190
Mississippi	27	0	27	24	9.7	12	21	21	37	12	49	45
Missouri	68	24	92	39	17	48	65	38	85	72	160	98
Montana	60	0	60	60	14	14	28	28	74	14	88	88
Nebraska	49	0	49	49	93	23	120	110	140	23	170	160
Nevada	11	0.7	11	6.6	3.7	8.5	12	8.9	14	9.2	24	15
New Hampshire	9.1	0.2	9.3	0.5	0.2	0.5	0.8	0.7	9.3	0.8	10	1.2
New Jersey	75	0	75	15	2.0	1.0	3.0	2.3	77	1.0	78	17
New Mexico	32	1.1	33	15	9.6	9.6	19	9.6	42	11	52	25
New York	130	0	130	13	37	20	58	52	170	20	190	65
North Carolina	140	0	140	140	33	5.6	39	39	170	5.6	170	170
North Dakota	11	0.2	11	11	13	8.2	21	21	24	8.4	32	32
Ohio	80	8.8	89	[illegible]	24	16	40	38	100	25	130	98
Oklahoma	29	5.2	35	31	8.2	50	58	58	38	55	93	89
Oregon	130	19	150	150	7.1	19	26	26	140	38	170	170
Pennsylvania	150	0	150	15	54	7.0	61	41	200	7.0	210	56
Rhode Island	4.9	0	4.9	0.8	0.1	0.1	0.2	0.2	5.0	0.1	5.1	1.0
South Carolina	65	0.2	65	65	12	10	22	22	77	10	87	87
South Dakota	21	1.4	22	16	81	11	92	85	100	12	110	100
Tennessee	43	0	43	12	7.0	35	42	43	50	35	85	54
Texas	130	0	130	130	120	150	270	270	250	150	400	400
Utah	26	3.3	29	10	31	9.0	40	11	57	12	69	21
Vermont	17	2.6	20	1.0	5.7	3.5	9.2	9.2	23	6.1	29	10
Virginia	150	0.1	150	74	2.3	26	28	17	150	26	180	91
Washington	40	11	52	18	4.1	2.0	6.1	3.0	44	13	58	21
West Virginia	18	1.3	19	0.2	1.0	6.6	7.6	6.7	19	7.9	27	6.9
Wisconsin	72	0	72	7.0	72	3.0	75	75	140	3.0	150	82
Wyoming	8.8	0.8	9.6	6.7	3.1	12	15	15	12	13	25	21
Puerto Rico	3.0	3.0	6.0	1.0	15	15	30	7.0	18	18	36	8.0
Virgin Islands	2.0	0.1	2.1	1.0	0	0.1	0.1	0.1	2.0	0.2	2.2	1.1
Total	3,300	180	3,400	2,000	1,200	980	2,200	1,900	4,400	1,200	5,600	3,900

Table 4.—*RURAL FRESH-WATER USE, BY REGIONS, IN MILLION GALLONS PER DAY, 1980*

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

WATER-RESOURCES REGION	DOMESTIC USE				LIVESTOCK USE				TOTAL DOMESTIC AND LIVESTOCK USE			
	Withdrawals			Consumptive use	Withdrawals			Consumptive use	Withdrawals			Consumptive use
	By source		Total		By source		Total		By source		Total	
	Ground water	Surface water			Ground water	Surface water			Ground water	Surface water		
New England..........	130	1.1	130	63	4.5	4.7	9.2	9.2	140	5.8	140	73
Mid-Atlantic..........	430	2.4	430	110	79	32	110	80	510	35	550	190
South Atlantic-Gulf..	720	0.4	720	440	130	110	240	240	850	110	960	670
Great Lakes..........	270	2.9	270	74	64	20	84	77	330	23	350	150
Ohio.................	290	21	310	200	63	90	150	140	360	110	470	350
Tennessee............	61	0	61	38	12	29	41	40	73	29	100	79
Upper Mississippi....	290	10	300	190	220	51	270	270	510	61	570	460
Lower Mississippi....	94	0.5	94	67	17	25	42	41	110	25	140	110
Souris-Red-Rainy.....	23	0	23	23	9.8	3.8	14	14	33	3.8	37	37
Missouri Basin.......	210	22	230	170	270	120	390	380	480	130	630	550
Arkansas-White-Red...	130	23	160	120	85	150	240	230	210	180	390	350
Texas-Gulf...........	120	0	120	120	78	120	190	190	200	120	310	310
Rio Grande...........	33	0.7	33	18	24	6.0	32	26	58	6.7	65	44
Upper Colorado.......	15	63	58	17	2.4	91	94	22	18	150	150	39
Lower Colorado.......	37	0.1	37	27	12	5.2	17	11	48	5.4	54	38
Great Basin..........	32	3.8	36	14	34	12	46	17	66	16	82	30
Pacific Northwest....	230	32	270	200	21	34	55	49	250	66	320	250
California...........	130	9.4	140	84	36	50	86	47	170	60	220	130
Alaska...............	11	0.1	11	0.1	0	0.1	0.2	0.2	11	0.3	11	0.3
Hawaii...............	5.5	0.4	5.9	3.4	5.3	0.2	5.5	4.8	8.8	0.6	9.4	8.2
Caribbean............	5.0	3.1	8.1	2.0	15	15	30	7.1	20	18	38	9.1
Total............	3,300	180	3,400	2,000	1,200	980	2,200	1,900	4,400	1,200	5,600	3,900

Irrigation

Irrigation of crops developed along with the settlement of the arid West because most years farmers needed to irrigate to raise any crops. In the humid eastern States, irrigation has been used to supplement natural rainfall in order to increase the number of plantings per year and yield of crops per acre, and to reduce the risk of crop failures during drought periods. Irrigation also is used to maintain recreational lands such as parks and golf courses. Estimates of withdrawals for irrigation vary greatly. In some instances, they are based on subjective amounts of water required to raise an acre of a given crop. In other instances, accurate records of water application rates are available. Reliable estimates of water withdrawn for irrigation can be made if the number of acres irrigated and the water application rates are known. It usually is difficult to obtain reliable estimates for consumptive use and for conveyance loss. Thus, some of the estimates of consumptive use and conveyance loss may be only rough approximations of actual conditions. Nevertheless, it is likely that better estimates were made of water used per acre in 1980 than in 1975, and in particular, the values given for conveyance loss for 1980 are more realistic because of progressively better records being kept by the water users.

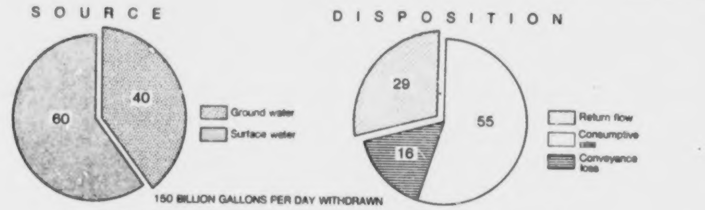
The quantity of water withdrawn for irrigation in 1980 was estimated at about 170 million acre-feet or 150 bgd. (See tables 5 and 6.) The water was used on approximately 58 million acres of farmland. This represents an increase in both water use and irrigated acreage of about 7 percent from the 1975 estimate. Where irrigation is used primarily to supplement natural rainfall, it is to be expected that there normally will be large differences in irrigation withdrawals from year to year.

The consumptive use of irrigation water was estimated to be 93 million acre-feet or 83 bgd in 1980. This was 55 percent of the irrigation water withdrawn, and accounted for about 81 percent of the total consumptive use by the Nation. Conveyance loss was estimated at about 26 million acre-feet (24 bgd) or 16 percent of 1980 irrigation withdrawals. Consumptive use and conveyance losses in 1980 were slightly higher than in 1975 but were essentially in the same proportion to irrigation water withdrawn as they were in 1975.

Surface water was the source of about 60 percent of the irrigation water (the same as 1975) and, except for a small fraction of 1 percent that was reclaimed sewage, ground water furnished the remainder.

The nine western water-resources regions (regions 10–18), led by the California region, accounted for 91 percent of the total water withdrawn for irrigation in 1980, compared to 93 percent in 1975. In the eastern regions, most of the water used for irrigation was in the South Atlantic-Gulf and Lower Mississippi regions, which together withdrew over 3 bgd more water in 1980 than in 1975. The State of California was by far the largest user of irrigation water, withdrawing about 37 bgd, 25 percent of the national total, which is more than the next two largest users, Idaho and Colorado, combined. Nebraska and Georgia showed the largest increase in number of acres irrigated from 1975 to 1980.

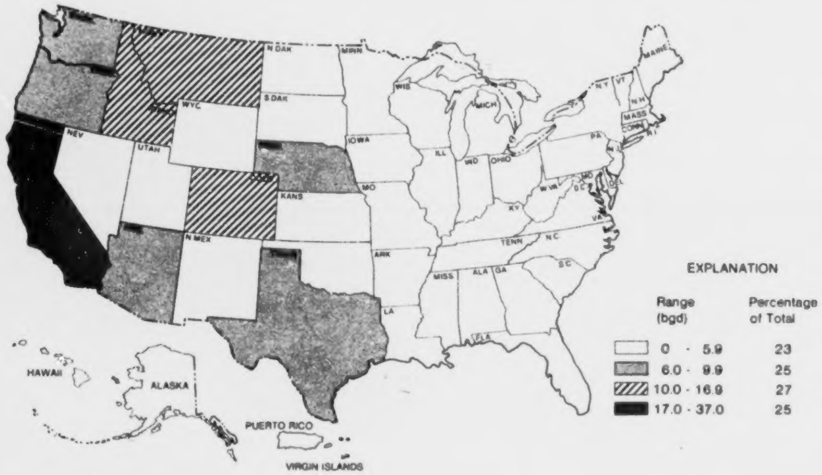
The range in irrigation water withdrawals, by States and water-resources regions is shown in figure 3. A comparison of withdrawals for self-supplied industrial use and irrigation use by both States and water-resources regions is shown in figure 10. Irrigation water-use data by States are given in table 5 and the same data by water-resources regions are given in table 6. The source of and disposition of withdrawals for irrigation use are shown in the chart below.



150 BILLION GALLONS PER DAY WITHDRAWN

WATER WITHDRAWN FOR IRRIGATION BY SOURCE AND DISPOSITION, 1980, IN PERCENT

A. States



B. Water-resources regions

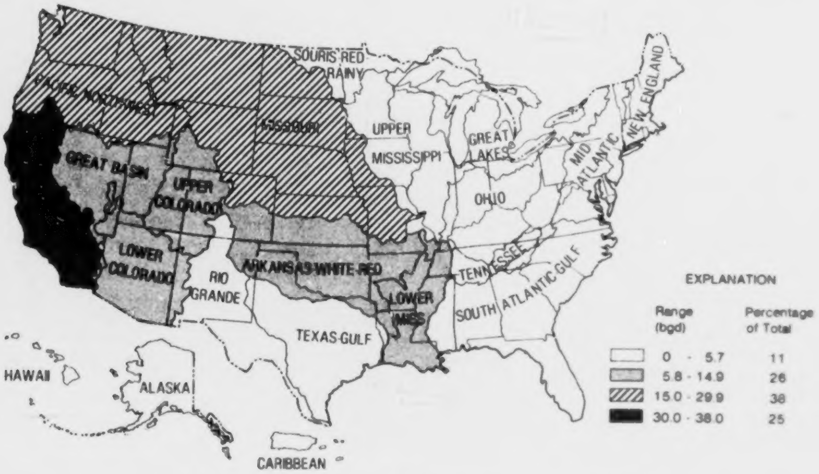


Figure 3. Irrigation water withdrawals, by States and water-resources regions, 1980.

Table 5.—*IRRIGATION WATER USE, BY STATES, IN THOUSAND ACRE-FEET PER YEAR AND MILLION GALLONS PER DAY, 1980*

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

STATE	IRRIGATED LAND, in thousand acres	THOUSAND ACRE-FEET PER YEAR						MILLION GALLONS PER DAY					
		Withdrawals				Convey-ance losses	Consump-tive use, fresh water	Withdrawals				Convey-ance losses	Consump-tive use, fresh water
		By source			Total			By source			Total		
		Fresh water		Re-claimed sewage				Fresh water		Re-claimed sewage			
		Ground	Surface					Ground	Surface				
Alabama	75	11	27	0	37	0	37	9.4	24	0	33	0	33
Alaska	0	0	0	0	0	0	0	0	0	0	0	0	0
Arizona	1300	4100	3800	3.9	8000	1000	4400	3700	3400	3.4	7100	900	4000
Arkansas	1800	3900	1800	0	5700	310	3500	3500	1600	0	5100	270	3100
California	9700	20000	22000	170	42000	6300	25000	18000	19000	150	37000	5600	23000
Colorado	2700	3000	12000	0	16000	1800	4100	2700	11000	0	14000	1600	3600
Connecticut	17	1.8	21	0	23	0	23	1.6	19	0	21	0	21
Delaware	10	4.6	2.7	0	7.3	0	7.3	4.1	2.4	0	6.5	0	6.5
D.C.	0	0	0	0	0	0	0	0	0	0	0	0	0
Florida	2000	1800	1600	0	3400	40	1700	1600	1400	0	3000	35	1500
Georgia	1000	420	230	0	650	0	650	380	200	0	580	0	580
Hawaii	140	520	500	0	1000	340	680	460	450	0	910	300	610
Idaho	4000	4500	13000	15	18000	4000	6300	4100	12000	13	16000	3600	5600
Illinois	150	110	5.9	0	120	0	120	100	5.3	0	110	0	110
Indiana	65	240	24	0	260	0	260	210	21	0	230	0	230
Iowa	150	55	7.5	0	62	0	62	49	6.7	0	56	0	56
Kansas	3400	5800	490	0	6300	160	4900	5200	440	0	5600	150	4300
Kentucky	14	0.3	5.2	0	5.5	0	5.5	0.2	4.7	0	4.9	0	4.9
Louisiana	760	1100	1400	0	2500	690	1800	990	1300	0	2200	610	1600
Maine	11	0.2	6.6	0	6.8	0	6.5	0.2	5.9	0	6.1	0	5.8
Maryland	33	11	11	0.1	22	0	22	10	9.4	0.1	20	0	19
Massachusetts	45	6.1	15	0	21	0	21	5.4	14	0	19	0	19
Michigan	320	86	120	33	240	0	240	77	110	30	210	0	210
Minnesota	460	160	20	0	180	0	180	140	18	0	160	0	160
Mississippi	480	950	150	0	1100	110	560	840	130	0	980	99	500
Missouri	240	110	33	0	140	0	120	98	30	0	130	0	100
Montana	2600	120	12000	0	12000	2700	2900	110	10000	0	11000	2400	2600
Nebraska	7100	7500	2900	0	10000	2100	8300	6700	2600	0	9300	1900	7400
Nevada	850	590	2900	3.7	3500	800	1700	530	2600	3.3	3100	720	1500
New Hampshire	1.8	0	1.8	0	1.8	0	1.5	0	1.6	0	1.6	0	1.3
New Jersey	75	45	17	0	62	0	50	40	15	0	55	0	45
New Mexico	1400	1800	2200	0	4000	35	1900	1600	2000	0	3600	31	1700
New York	56	24	28	0	51	0	51	21	25	0	46	0	46
North Carolina	150	44	100	0	150	0	150	39	93	0	130	0	130
North Dakota	180	73	240	0.4	310	34	280	65	210	0.4	280	30	250
Ohio	48	2.1	3.8	0	5.9	0	5.4	1.9	3.4	0	5.3	0	4.8
Oklahoma	900	820	160	0	980	59	690	730	140	0	870	53	610
Oregon	2100	950	5700	4.0	6600	1900	3300	850	5000	3.6	5900	1700	3000
Pennsylvania	63	25	160	0	180	0	180	22	140	0	160	0	160
Rhode Island	4.0	0.6	5.1	0	5.6	0.6	5.0	0.5	4.5	0	5.0	0.5	4.5
South Carolina	73	19	42	0	61	0	61	17	37	0	54	0	54
South Dakota	390	170	340	1.7	510	47	380	150	310	1.5	460	42	340
Tennessee	21	7.2	6.8	0	14	0.7	10	6.4	6.1	0	12	0.6	9.1
Texas	7700	7300	2100	78	9500	230	9000	6500	1900	70	8400	200	8000
Utah	1200	600	3000	0	3600	360	2700	530	2700	0	3200	320	2400
Vermont	1.6	0.3	1.3	0	1.6	0	1.2	0.3	1.2	0	1.4	0	1.0
Virginia	41	9.4	22	0	31	4.3	19	8.4	19	0	28	3.9	17
Washington	1600	300	6900	0	7200	1300	2900	260	6100	0	6400	1200	2600
West Virginia	2.4	0.1	1.4	0	1.5	0	1.5	0.1	1.2	0	1.3	0	1.3
Wisconsin	240	92	3.4	0	95	0	86	82	3.0	0	85	0	77
Wyoming	1800	420	5000	0	5400	1800	2800	370	4500	0	4900	1600	2500
Puerto Rico	75	150	200	0	350	34	220	140	180	0	310	30	200
Virgin Islands	0.5	0	0	0	0	0	0	0	0	0	0	0	0
Total	58,000	68,000	100,000	310	170,000	26,000	93,000	60,000	90,000	280	150,000	24,000	83,000

Table 6.—*IRRIGATION WATER USE, BY REGIONS, IN THOUSAND ACRE-FEET PER YEAR AND MILLION GALLONS PER DAY, 1980*

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

WATER-RESOURCES REGION	IRRIGATED LAND, in thousand acres	THOUSAND ACRE-FEET PER YEAR						MILLION GALLONS PER DAY					
		Withdrawals				Convey-ance losses	Consump-tive use, fresh water	Withdrawals				Convey-ance losses	Consump-tive use, fresh water
		By source			Total			By source			Total		
		Fresh water		Re-claimed sewage				Fresh water		Re-claimed sewage			
		Ground	Surface					Ground	Surface				
New England..........	79	8.7	50	0	59	0.6	58	7.8	45	0	53	0.5	52
Mid-Atlantic..........	230	110	170	0.1	280	1.9	270	97	150	0.1	250	1.7	240
South Atlantic-Gulf..	3600	2300	2000	0	4300	42	2600	2000	1800	0	3800	38	2300
Great Lakes..........	450	200	140	33	380	0	370	180	120	30	340	0	330
Ohio..................	86	99	68	0	170	0.1	160	88	60	0	150	0.1	150
Tennessee............	14	3.0	4.7	0	7.6	0.2	7.4	2.7	4.1	0	6.8	0.2	6.6
Upper Mississippi....	830	390	32	0	420	0	410	350	29	0	380	0	370
Lower Mississippi....	2900	5400	3200	0	8700	1100	5400	4800	2900	0	7700	960	4800
Souris-Red-Rainy.....	120	52	20	0.2	72	4.4	67	46	18	0.2	64	3.9	60
Missouri Basin.......	14000	12000	20000	1.9	32000	6600	16000	11000	18000	1.7	28000	5900	15000
Arkansas-White-Red...	7000	9500	2700	17	12000	400	9100	8400	2400	15	11000	360	8200
Texas-Gulf...........	5200	4300	1800	62	6200	180	5500	3900	1600	55	5500	160	4900
Rio Grande...........	1400	1800	3000	0	4800	330	2400	1600	2700	0	4300	290	2100
Upper Colorado.......	1300	90	8300	0.1	8400	930	2200	81	7400	0.1	7500	830	2000
Lower Colorado.......	1400	4400	4200	7.0	8500	1100	4800	3900	3700	6.2	7600	950	4300
Great Basin..........	1900	1100	5500	4.1	6600	1100	3900	1000	4900	3.7	5900	1000	3500
Pacific Northwest....	7700	5700	27000	19	33000	7600	12000	5100	24000	17	29000	6800	11000
California...........	10000	20000	22000	170	42000	6500	26000	18000	20000	150	38000	5800	23000
Alaska.........	0	0	0	0	0	0	0	0	0	0	0	0	0
Hawaii...............	140	520	500	0	1000	340	680	460	450	0	910	300	610
Caribbean............	76	150	200	0	350	34	220	140	180	0	310	30	200
Total.............	58,000	68,000	100,000	310	170,000	26,000	93,000	60,000	90,000	280	150,000	24,000	83,000

Self-Supplied Industrial

All Self-Supplied Industrial Use (Thermoelectric Power and Other Industries)

Self-supplied industrial water use is categorized in this report as thermoelectric power (electric utility) and "other" self-supplied water-using industries (see tables 7 and 8). "Other" self-supplied water-using industries include, but are not limited to, steel, chemical and allied products, paper and allied products, mining, and petroleum refining. Thermoelectric power plants can be powered by fossil-fuel, geothermal, or nuclear energy, and account for the largest quantity of water withdrawn for offstream use. (See table 22.) Because of the magnitude of water required for thermoelectric power generation, the estimates of use are discussed here as part of the total self-supplied industrial use and in more detail in a separate section (see page 25 and tables 9 and 10). Self-supplied industrial water systems often are metered and estimates of water withdrawn and consumed generally are reliable. It is likely that better estimates were made in 1980 than in 1975 because more comprehensive inventories were obtained and more accurate and complete records were available from the users.

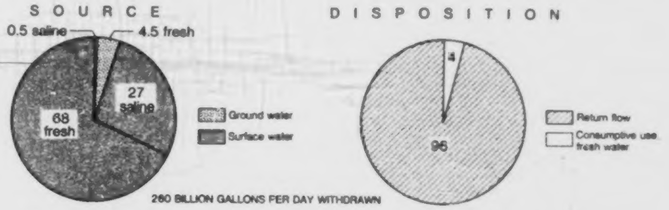
More water continues to be withdrawn for industrial use than for any other category. In 1980, the amount of self-supplied industrial water withdrawn was estimated at 260 bgd of which about 72 bgd was saline (see tables 7 and 8), this is an increase of 8 percent from the 1975 estimate. Of the 260 bgd, about 210 bgd or 83 percent of all industrial withdrawals was withdrawn by thermoelectric power plants (see tables 9 and 10). Withdrawals for thermoelectric power plants showed a 9-percent increase from 1975, and withdrawals for "other" industrial uses (about 45 bgd) remained about the same as in 1975. Saline water constituted about 28 percent of the total self-supplied industrial withdrawals, approximately the same proportion as in 1965, 1970, and 1975. Public-supply systems delivered about 2 bgd for thermoelectric power generation and about 10 bgd for other industrial and commercial uses. The withdrawal estimates for thermoelectric power plants (see tables 9 and 10) include the water from public supplies; however, public supplies are not included in the estimate for total self-supplied industrial use (tables 7 and 8) but are summarized in the public-supply category (see tables 1 and 2).

Consumptive use of fresh water by thermoelectric plants was about 2 percent and for other self-supplied industrial uses about 13 percent, giving a combined consumptive use of about 4 percent for all types of self-supplied industries. Saline water consumed by thermoelectric plants also was about 2 percent of the saline withdrawals, and about 15 percent for other industrial uses. These consumptive use figures are higher than in previous years and indicate an increased reuse of water.

The relative proportion of source of supply has remained constant since 1965—ground water still supplied nearly 5 percent, surface water about 95 percent, and reclaimed sewage only a fraction of 1 percent.

The Mid-Atlantic water-resources region withdrew slightly more water for industrial use in 1980 than in 1975 and withdrew the most saline water and total water (fresh and saline). The Ohio region withdrew about 6 percent more water for industrial use in 1980 than in 1975 and accounted for the most fresh-water withdrawals. Withdrawals in the State of Illinois for self-supplied industrial use increased 50 percent from 1975 to 1980, based on a more complete inventory of industrial users, making Illinois the second largest user of self-supplied industrial water behind Florida.

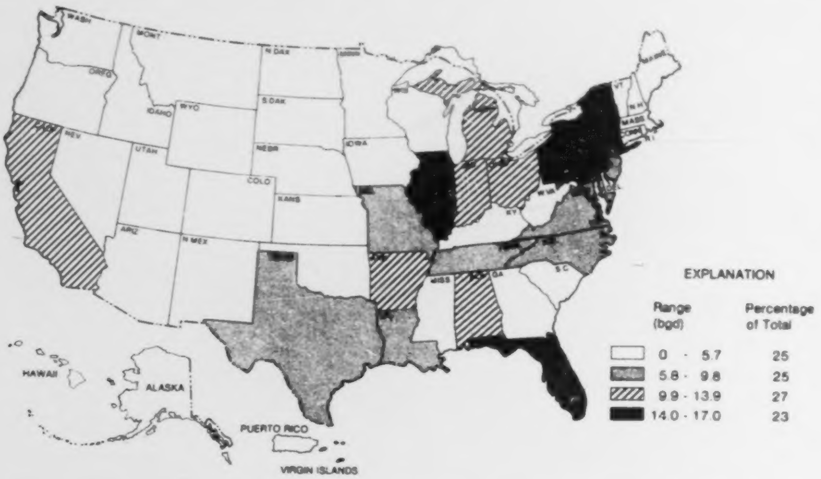
The range in self-supplied industrial water withdrawals by States and water-resources regions is shown in figure 4. A comparison of withdrawals for self-supplied industrial use and irrigation use by both States and water-resources regions is shown in figure 10. Self-supplied industrial water-use data by States are given in table 7, and the same data by water-resources regions are given in table 8. The source of and disposition of withdrawals for self-supplied industrial use are shown in the chart below.



260 BILLION GALLONS PER DAY WITHDRAWN

WATER WITHDRAWN FOR ALL SELF-SUPPLIED INDUSTRIAL USE BY SOURCE AND DISPOSITION, 1980 IN PERCENT

A. States



B. Water-resources regions

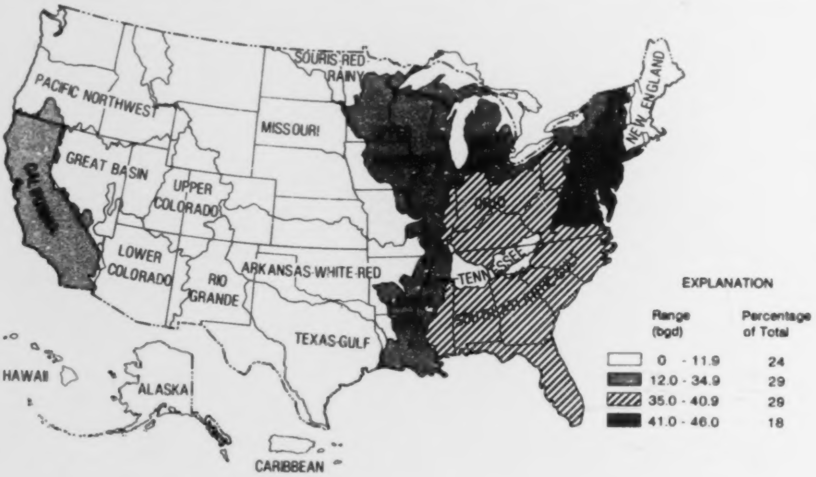


Figure 4. Self-supplied industrial water withdrawals, by States and water-resources regions, 1980.

Table 7.—*SELF-SUPPLIED INDUSTRIAL WATER USE, BY STATES, IN MILLION GALLONS PER DAY, 1980*

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

STATE	ALL SELF-SUPPLIED INDUSTRIAL USE												
	Withdrawals										Consumptive use		
	By source and type							Total, excluding reclaimed sewage					
	Ground water			Surface water			Reclaimed sewage						
	Fresh	Saline	Total	Fresh	Saline	Total		Fresh	Saline	Total	Fresh	Saline	Total
Alabama	53	1.4	54	9700	73	9800	0	9800	75	9900	300	1.3	300
Alaska	14	0	14	140	0	140	0	160	0	160	1.5	0	1.5
Arizona	180	0	180	69	0	69	1.6	250	0	250	170	.8	170
Arkansas	320	0	320	9900	0	9900	0	10000	0	10000	300	0	300
California	1300	250	1600	1160	9800	11000	8.9	2400	10000	12000	230	100	330
Colorado	16	0	16	890	0	890	0	910	0	910	170	0	170
Connecticut	27	1.0	28	860	2400	3200	0	880	2400	3300	21	0	21
Delaware	21	.3	21	6.2	1100	1100	0	27	1100	1100	2.6	110	110
D.C.	0.8	0	0.8	130	0	130	0	130	0	130	2.3	0	2.3
Florida	710	42	750	1900	14000	16000	0	2600	14000	17000	500	55	550
Georgia	400	0	400	4700	200	4900	0	5100	200	5300	180	2.0	180
Hawaii	140	0	140	65	1200	1300	10	190	1200	1400	0	0	0
Idaho	2100	0	2100	120	0	120	0	2200	0	2200	180	0	180
Illinois	220	38	260	16000	0	16000	0	16000	38	16000	350	0	350
Indiana	640	0	640	12000	0	12000	0	13000	0	13000	230	0	230
Iowa	320	0	320	3400	0	3400	0	3800	0	3800	31	0	31
Kansas	190	0	190	340	0	340	0	530	0	530	110	0	110
Kentucky	150	0	150	4200	0	4200	0	4400	0	4400	180	0	180
Louisiana	440	19	460	8900	390	9300	0	9400	410	9800	870	38	910
Maine	34	0	34	670	710	1400	0	710	710	1400	8.9	0	8.9
Maryland	37	0	37	520	6600	7100	160	560	6600	7100	17	22	39
Massachusetts	93	0	93	1500	3500	5000	0	1600	3500	5100	25	5	30
Michigan	62	420	480	13000	0	13000	0	13000	420	14000	99	120	220
Minnesota	120	0	120	2200	0	2200	0	2300	0	2300	65	0	65
Mississippi	370	0	370	1200	660	1900	0	1600	660	2200	69	20	89
Missouri	130	0	130	5700	0	5700	0	5800	0	5800	320	0	320
Montana	32	2.1	34	250	0	250	0	280	2.1	280	28	.8	29
Nebraska	89	0	89	2200	0	2200	0	2300	0	2300	25	0	25
Nevada	71	9.0	80	160	0	160	11	230	9.0	240	79	7.6	86
New Hampshire	13	0	13	270	620	900	0	280	620	910	10	0	10
New Jersey	160	0	160	1500	7500	9000	0	1700	7500	9200	120	570	690
New Mexico	18	.9	18	54	0	54	0	71	.9	72	59	.4	59
New York	250	12	260	5300	8600	14000	0	5500	8600	14000	100	46	150
North Carolina	490	0	490	6700	42	6700	0	7200	42	7200	340	11	350
North Dakota	3.4	.2	3.6	930	0	930	0	930	.2	930	18	.1	18
Ohio	500	0	500	11000	0	11000	0	12000	0	12000	270	0	270
Oklahoma	100	95	200	350	0	350	0	450	95	540	220	95	320
Oregon	80	0	80	440	0	440	0	520	0	520	20	0	20
Pennsylvania	560	0	560	13000	93	13000	0	14000	93	14000	550	1.0	550
Rhode Island	13	0	13	23	330	350	0	35	330	360	2.9	0	2.9
South Carolina	58	0	58	5600	38	5700	0	5700	38	5700	83	.1	83
South Dakota	26	3.4	29	21	0	21	0	47	3.4	50	5.5	3.4	8.9
Tennessee	190	0	190	9300	0	9300	0	9500	0	9500	150	0	150
Texas	360	0	360	1600	6600	8000	0	1700	6600	8300	980	920	1900
Utah	68	4.0	72	460	56	510	0	520	60	580	90	45	130
Vermont	5.2	0	5.2	260	0	260	0	260	0	260	24	0	24
Virginia	110	.2	110	4700	4100	8800	0	4800	4100	8900	90	48	140
Washington	150	0	150	830	42	880	0	990	42	1000	150	6.3	150
West Virginia	150	0	150	5300	0	5300	0	5400	0	5400	190	0	190
Wisconsin	97	0	97	4900	0	4900	0	5000	0	5000	91	0	91
Wyoming	130	24	150	270	0	270	0	390	24	420	71	0	71
Puerto Rico	88	5.0	93	30	2400	2400	0	120	2400	2500	26	0	26
Virgin Islands	0	0	0	0	32	32	0	0	32	32	.2	4.0	4.2
Total	12,000	930	13,000	180,000	71,000	250,000	190	190,000	72,000	260,000	8,200	2,200	10,000

Table 7.—*SELF-SUPPLIED INDUSTRIAL WATER USE, BY STATES, IN MILLION GALLONS PER DAY, 1980* Continued

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

STATE	TYPE OF SELF-SUPPLIED INDUSTRIAL USE														
	Thermoelectric power (electric utility)[1]						Other industries								
	Withdrawals, by source			Total fresh water	Consumptive use		Withdrawals, by source					Total, excluding reclaimed sewage		Consumptive use	
	Fresh ground water	Surface water					Ground water		Surface water		Reclaimed sewage				
		Fresh	Saline		Fresh	Saline	Fresh	Saline	Fresh	Saline		Fresh	Saline	Fresh	Saline
Alabama	1.5	8500	73	8500	29	0.1	51	1.4	1200	0.2	0	1300	1.6	270	1.2
Alaska	8.4	22	0	30	0.3	0	6.1	0	120	0	0	130	0	1.2	0
Arizona	40	49	0	89	31	0.8	140	0	20	0	1.8	160	0	120	0
Arkansas	3.1	9700	0	9700	100	0	320	0	190	0	0	510	0	200	0
California	890	1100	9200	2000	41	60	420	250	45	560	8.9	470	820	190	41
Colorado	9.4	160	0	170	97	0	7.1	0	730	0	0	730	0	73	0
Connecticut	0.2	610	2400	610	1.9	0	26	1.0	250	1.0	0	270	2.0	19	0
Delaware	5.4	0	670	5.4	0.5	67	15	0.3	6.2	390	0	22	390	2.1	39
D.C.	0	130	0	130	2.0	0	0.8	0	0.6	0	0	1.4	0	0.3	0
Florida	70	1800	14000	1900	32	48	640	42	140	15	0	780	57	470	6.4
Georgia	4.1	4400	160	4400	120	0	400	0	380	42	0	780	42	59	2.0
Hawaii	130	9.0	1200	140	0	0	9.1	0	36	7.0	10	45	7.0	0	0
Idaho	5.3	0	0	5.3	1.3	0	2100	0	120	0	0	2200	0	170	0
Illinois	8.4	14000	0	14000	280	0	210	38	1600	0	0	1800	38	88	0
Indiana	5.0	9700	0	9700	65	0	640	0	2500	0	0	3100	0	160	0
Iowa	4.0	3200	0	3200	20	0	320	0	230	0	0	550	0	11	0
Kansas	46	300	0	350	39	0	140	0	41	0	0	180	0	66	0
Kentucky	15	4000	0	4100	140	0	130	0	190	0	0	320	0	33	0
Louisiana	46	5800	180	5900	320	9.1	390	19	3100	210	0	3500	230	550	29
Maine	1.0	55	700	56	0	0	33	0	620	11	0	650	11	8.9	0
Maryland	3.0	400	6100	410	2.0	17	34	0	120	500	160	150	500	15	5.0
Massachusetts	0	1300	3600	1300	0	0	93	0	220	64	0	310	64	25	5.1
Michigan	0	12000	0	12000	0	0	62	420	1600	0	0	1700	420	99	120
Minnesota	2.2	1700	0	1700	7.2	0	120	0	470	0	0	590	0	58	0
Mississippi	17	1100	500	1100	33	3.5	360	0	97	160	0	450	160	36	16
Missouri	16	5500	0	5500	300	0	120	0	190	0	0	300	0	24	0
Montana	0	180	0	180	12	0	32	2.1	76	0	0	110	2.1	15	0.8
Nebraska	31	2200	0	2200	22	0	58	0	6.3	0	0	64	0	3.1	0
Nevada	8.1	86	0	94	20	0	63	9.0	74	0	11	140	9.0	58	7.6
New Hampshire	0	74	620	74	0	0	13	0	200	0	0	210	0	10	0
New Jersey	5.0	910	6500	910	70	500	150	0	600	1000	0	750	1000	58	65
New Mexico	11	54	0	65	55	0	6.6	0.9	0.1	0	0	6.6	0.9	4.2	0.4
New York	130	4300	8500	4400	4.6	34	120	12	980	120	0	1100	130	96	11
North Carolina	0	4300	6.4	4300	67	7.8	490	0	2400	36	0	2900	36	270	3.5
North Dakota	1.2	920	0	930	16	0	2.2	0.2	4.7	0	0	7.0	0.2	4.3	0.1
Ohio	21	10000	0	10000	93	0	470	0	1500	0	0	2000	0	180	0
Oklahoma	7.7	170	0	180	110	0	95	95	170	0	0	270	95	120	95
Oregon	0	22	0	22	0	0	80	0	420	0	0	500	0	20	0
Pennsylvania	6.8	10000	93	10000	290	1.0	550	0	3100	0	0	3600	0	260	0
Rhode Island	0	0.1	330	0.1	0	0	13	0	23	0.6	0	35	0.6	2.9	0
South Carolina	0.5	5200	7.7	5200	35	0.1	57	0	400	30	0	460	30	47	0
South Dakota	2.4	2.5	0	4.9	3.2	0	23	3.4	19	0	0	42	3.4	2.3	3.4
Tennessee	0	7800	0	7800	1.0	0	190	0	1500	0	0	1700	0	150	0
Texas	38	960	5500	990	500	470	320	0	410	1100	0	730	1100	490	450
Utah	0.2	64	5.9	64	9.9	4.6	68	4.0	390	50	0	460	54	80	40
Vermont	0	250	0	250	22	0	5.2	0	9.6	0	0	15	0	2.3	0
Virginia	1.2	4300	4000	4300	43	40	110	0.2	360	81	0	470	81	47	8.1
Washington	0	1.3	0	1.3	1.1	0	150	0	830	42	0	990	42	150	6.3
West Virginia	0	4600	0	4600	110	0	150	0	680	0	0	830	0	82	0
Wisconsin	1.2	4500	0	4500	46	0	96	0	350	0	0	450	0	45	0
Wyoming	1.1	220	0	220	45	0	130	24	44	0	0	170	24	25	0
Puerto Rico	3.0	0	1500	3.0	6.0	0	85	5.0	30	920	0	120	930	20	0
Virgin Islands	0	0	32	0	0.2	4.0	0	0	0	0	0	0	0	0	0
Total	1,600	150,000	65,000	150,000	3,200	1,300	10,000	930	29,000	5,400	190	39,000	6,300	5,000	970

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[1] See Table 9 for additional information.

Table 8.—*SELF-SUPPLIED INDUSTRIAL WATER USE, BY REGIONS, IN MILLION GALLONS PER DAY, 1980*

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

WATER-RESOURCES REGION	ALL SELF-SUPPLIED INDUSTRIAL USE												
	Withdrawals										Consumptive use		
	By source and type							Total, excluding reclaimed sewage					
	Ground water			Surface water			Re-claimed sewage						
	Fresh	Saline	Total	Fresh	Saline	Total		Fresh	Saline	Total	Fresh	Saline	Total
New England	180	1.0	180	3600	7500	11000	0	3700	7500	11000	87	5.1	92
Mid-Atlantic	690	12	700	18000	28000	45000	160	18000	28000	46000	540	780	1300
South Atlantic-Gulf	1800	44	1900	23000	15000	38000	0	25000	15000	40000	1300	92	1400
Great Lakes	660	420	1100	32000	0	32000	0	33000	420	33000	470	120	590
Ohio	1300	24	1300	34000	0	34000	0	35000	24	35000	930	0	930
Tennessee	97	0	97	11000	0	11000	0	11000	0	11000	240	0	240
Upper Mississippi	660	15	670	19000	0	19000	0	20000	15	20000	470	0	470
Lower Mississippi	1100	19	1100	11000	390	11000	0	12000	410	12000	1100	38	1200
Souris-Red-Rainy	5.1	0	5.1	59	0	59	0	64	0	64	6.6	0	6.6
Missouri Basin	430	26	450	8400	0	8400	0	8800	26	8900	420	4.5	430
Arkansas-White-Red	390	95	480	10000	2.0	10000	0	11000	97	11000	740	96	840
Texas-Gulf	270	0	270	1200	6600	7800	0	1500	6600	8100	710	920	1600
Rio Grande	30	.9	31	3.0	0	3.0	0	33	.9	34	24	.4	25
Upper Colorado	23	3.5	26	700	.7	700	0	730	4.2	730	190	.1	190
Lower Colorado	200	.2	200	130	0	130	12	340	.2	340	200	.2	200
Great Basin	130	13	140	500	55	550	1.1	630	68	700	110	52	160
Pacific Northwest	2300	0	2300	1400	42	1500	0	3700	42	3800	350	6.3	360
California	1300	250	1600	1100	9800	11000	8.7	2500	10000	12000	230	100	330
Alaska	14	0	14	140	0	140	0	160	0	160	1.5	0	1.5
Hawaii	140	0	140	45	1200	1300	10	190	1200	1400	0	0	0
Caribbean	88	5.0	93	30	2500	2500	0	120	2500	2600	26	4.0	30
Total	12,000	930	13,000	180,000	71,000	250,000	190	190,000	72,000	260,000	8,200	2,200	10,000

Table 8.—*SELF-SUPPLIED INDUSTRIAL WATER USE, BY REGIONS, IN MILLION GALLONS PER DAY, 1980*—Continued

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

WATER-RESOURCES REGION	TYPE OF SELF-SUPPLIED INDUSTRIAL USE														
	Thermoelectric power (electric utility)[1]						Other industries								
	Withdrawals, by source			Total fresh water	Consumptive use		Withdrawals, by source					Total, excluding reclaimed sewage		Consumptive use	
	Fresh ground water	Surface water					Ground water		Surface water		Re-claimed sewage				
		Fresh	Saline		Fresh	Saline	Fresh	Saline	Fresh	Saline		Fresh	Saline	Fresh	Saline
New England	1.2	2300	7400	2300	21	0	180	1.0	1300	77	0	1500	78	66	5.1
Mid-Atlantic	110	15000	25000	15000	260	660	580	12	2900	2100	160	3400	2100	280	130
South Atlantic-Gulf	88	19000	15000	19000	270	63	1800	44	4100	280	0	5900	330	1100	29
Great Lakes	30	27000	0	27000	93	0	630	420	5100	0	0	5700	420	370	120
Ohio	52	30000	0	30000	520	0	1300	24	3700	0	0	5000	24	420	0
Tennessee	0	9300	0	9300	20	0	97	0	2000	0	0	2000	0	220	0
Upper Mississippi	13	16000	0	16000	290	0	650	15	2600	0	0	3300	15	170	0
Lower Mississippi	54	7700	180	7700	400	9.1	1000	19	3200	210	0	4300	230	740	29
Souris-Red-Rainy	0.9	53	0	54	1.0	0	4.2	0	5.1	0	0	9.3	0	5.6	0
Missouri Basin	48	8100	0	8200	350	0	380	26	300	0	0	680	26	77	4.5
Arkansas-White-Red	70	9900	0	10000	410	0	320	95	530	2.0	0	840	97	330	96
Texas-Gulf	30	950	5500	980	360	470	240	0	280	1100	0	520	1100	350	450
Rio Grande	15	2.5	0	17	11	0	15	0.9	0.5	0	0	16	0.9	13	0.4
Upper Colorado	0	140	0.7	140	130	0.1	23	3.5	560	0	0	590	3.5	63	0
Lower Colorado	45	45	0	90	49	0.8	160	0.2	86	0	12	250	0.2	150	0
Great Basin	4.5	120	5.2	130	5.9	4.5	130	13	370	50	1.1	500	63	100	48
Pacific Northwest	5.3	23	0	29	2.4	0	2300	0	1400	42	0	3700	42	350	6.3
California	890	1100	9200	2000	41	60	430	250	58	560	8.7	480	820	190	41
Alaska	8.4	22	0	30	0.3	0	6.1	0	120	0	0	130	0	1.2	0
Hawaii	130	9.0	1200	140	0	0	9.1	0	36	7.0	10	45	7.0	0	0
Caribbean	3.0	0	1500	3.0	6.1	4.0	85	5.0	30	920	0	120	930	20	0
Total	1,600	150,000	65,000	150,000	3,200	1,300	10,000	930	29,000	5,400	190	39,000	6,300	5,000	970

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[1] See Table 10 for additional information.

Self-Supplied Industrial

Thermoelectric Power

Thermoelectric power generation is categorized as a self-supplied industrial water use. However, because of the magnitude of water required, separate estimates were made of the source, use, and disposition of water for the thermoelectric power industry (tables 9 and 10). These estimates usually are reliable inasmuch as relatively complete data files are maintained by Federal and State agencies.

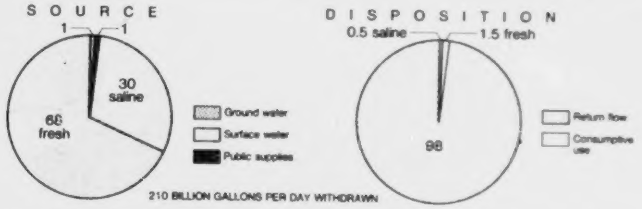
Thermoelectric power plants furnish practically all their own water; less than 1 percent is obtained from public supplies. In 1980, water withdrawn by thermoelectric power plants was about 210 bgd, an increase of about 9 percent from the 1975 estimate, and an increase of about 26 percent from the 1970 estimate. The thermoelectric power industry continues to withdraw the largest quantity of water for offstream use, more than 1.4 times the water withdrawn for irrigation, the next largest water-use category.

About 99 percent of the total water withdrawn by thermoelectric plants was used for condenser and reactor cooling of generators. Plants vary widely as to the techniques used in disposal of the cooling water after it has passed through the condensers. Where water is expensive or scarce, cooling towers or ponds (Federal Power Commission, 1969) are employed so that the same water can be used repeatedly in the condensers. Prevention of thermal pollution of the receiving water body is another factor that has caused some plants to resort to water-cooling devices. The quantity of water consumed by steamplants will increase as reuse of water becomes more prevalent. About 2 percent of the water withdrawn in 1980 was consumed, compared to 1 percent in 1975, and only one-half of 1 percent in 1970. Surface water constituted 98 percent of total thermoelectric withdrawals in 1980, and 30 percent was saline, compared to 33 percent in 1975 and 28 percent in 1970.

Public-supply systems delivered about 2 bgd for thermoelectric power generation. In previous reports in this series, a major part of this water was erroneously identified as self-supplied industrial withdrawals.

The amount of water withdrawn in the Mid-Atlantic water-resources region by thermoelectric power plants in 1980 was approximately the same as in 1975, and accounted for the most saline water and total water (fresh and saline) withdrawals. The Ohio region withdrew about 13 percent more water for thermoelectric power plants in 1980 than in 1975 and accounted for the most fresh-water withdrawals. Withdrawals in the State of Illinois for thermoelectric power generation increased 54 percent from 1975 to 1980, based on a more complete inventory of industrial users, making Illinois the second largest user of water for thermoelectric power after Florida. Arkansas withdrawals increased from about 2 bgd to nearly 10 bgd from 1975 to 1980, as the result of nuclear power plants coming online between 1975 and 1980.

Thermoelectric power water-use data by States, are given in table 9, and the same data by water-resources regions are given in table 10. The source of and disposition of withdrawals for thermoelectric power generation are shown in the chart below.



210 BILLION GALLONS PER DAY WITHDRAWN

WATER WITHDRAWN FOR THE GENERATION OF THERMOELECTRIC POWER BY SOURCE AND DISPOSITION, 1980, IN PERCENT

Table 9.—*THERMOELECTRIC POWER (ELECTRIC UTILITY GENERATION) WATER USE, BY STATES, IN MILLION GALLONS PER DAY, 1980*

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

STATE	WITHDRAWALS, BY TYPE OF USE AND SOURCE OF WATER										CONSUMPTIVE USE	
	Cooling of condensers and reactors					Other thermoelectric uses						
	Self supplied			Public supplies	Total	Self supplied			Public supplies	Total		
	Fresh ground water	Surface water				Fresh ground water	Surface water					
		Fresh	Saline				Fresh	Saline			Fresh	Saline
Alabama	0	8100	72	0	8200	1.5	390	1.5	0.1	400	29	0.1
Alaska	8.4	22	0	0.5	31	0	0	0	0	0	0.3	0
Arizona	38	45	0	0.7	85	1.7	3.4	0	0	5.1	31	0.8
Arkansas	2.6	9700	0	0	9700	0.4	0.2	0	0	0.7	100	0
California	890	1100	9200	0	11000	0	0	0	0	0	41	60
Colorado	9.4	160	0	0.2	170	0	0	0	0	0	97	0
Connecticut	0	610	2400	0.3	3000	0.2	0.2	0	190	190	1.9	0
Delaware	5.4	0	670	0	680	0	0	0	0	0	0.5	67
D.C.	0	130	0	0	130	0	0	0	0	0	2.0	0
Florida	63	1800	14000	0.5	16000	7.1	0	0	2.3	9.4	32	48
Georgia	0	4400	160	0	4500	4.1	1.2	0	0	5.3	120	0
Hawaii	130	9.0	1200	0	1400	0	0	0	0	0	0	0
Idaho	5.2	0	0	0	5.2	0.1	0	0	0	0.1	1.3	0
Illinois	0	14000	0	0	14000	8.4	25	0	2.5	36	260	0
Indiana	5.0	9700	0	0	9700	0	0	0	0	0	65	0
Iowa	4.0	3100	0	18	3100	0	92	0	0.7	93	20	0
Kansas	46	300	0	0	350	0	0	0	0	0	39	0
Kentucky	12	3900	0	0	3900	3.2	150	0	0.6	150	140	0
Louisiana	44	5600	170	0	5800	2.3	280	9.1	0	290	320	9.1
Maine	0	55	700	0	750	1.0	0	0	1.0	2.0	0	0
Maryland	1.0	390	6100	0	6500	2.0	10	0	0	12	2.0	17
Massachusetts	0	1300	3400	0	4700	0	0	0	0	0	0	0
Michigan	0	12000	0	0	12000	0	58	0	0	58	0	0
Minnesota	1.5	1700	0	0.6	1700	0.7	4.5	0	0	5.2	7.2	0
Mississippi	12	1100	500	22	1600	4.7	0	0	0	4.7	33	3.5
Missouri	2.3	5500	0	0	5500	13	0	0	0	13	300	0
Montana	0	170	0	0	170	0	4.4	0	0	4.4	12	0
Nebraska	31	2200	0	18	2200	0	0	0	0	0	22	0
Nevada	6.1	86	0	0	92	2.0	0	0	0.4	2.4	20	0
New Hampshire	0	74	620	0	700	0	0	0	0	0	0	0
New Jersey	0	900	6500	0	7400	5.0	5.0	0	5.0	15	70	500
New Mexico	11	54	0	0	65	0	0	0	0	0	55	0
New York	0	4000	8500	0	12000	130	240	0	3.7	370	4.6	34
North Carolina	0	4200	6.4	0	4200	0	77	0	0	77	67	7.8
North Dakota	0.8	920	0	0	920	0.4	7.8	0	0	8.2	14	0
Ohio	17	10000	0	1.1	10000	4.1	79	0	3.0	86	93	0
Oklahoma	7.5	170	0	15	190	0.2	3.8	0	0.4	4.5	110	0
Oregon	0	22	0	0	22	0	0	0	0	0	0	0
Pennsylvania	0	10000	93	0	10000	6.8	35	0	0.4	42	290	1.0
Rhode Island	0	0.1	330	0	330	0	0	0	0	0	0	0
South Carolina	0	5200	7.7	0	5200	0.5	7.4	0	0	7.9	35	0.1
South Dakota	2.3	2.5	0	0	4.8	0.1	0	0	0	0.1	3.2	0
Tennessee	0	7500	0	0	7500	0	270	0	0.2	270	1.0	0
Texas	35	940	5500	1800	8200	3.6	12	0	11	27	500	470
Utah	0	64	5.9	0	70	0.2	0	0	0.1	0.3	9.9	4.6
Vermont	0	220	0	0	220	0	22	0	0	22	22	0
Virginia	0	4300	4000	0	8400	1.2	0	0	0.1	1.3	43	40
Washington	0	1.3	0	0	1.3	0	0	0	0	0	1.1	0
West Virginia	0	4500	0	0	4500	0	110	0	0	110	110	0
Wisconsin	0	4500	0	0	4500	1.2	0	0	0	1.2	46	0
Wyoming	0.4	220	0	2.9	220	0.7	5.9	0	0	6.6	45	0
Puerto Rico	0	0	1500	0	1500	3.0	0	0	3.0	6.0	6.0	0
Virgin Islands	0	0	32	0	32	0	0	0	0.2	0.2	0.2	4.0
Total	1,400	150,000	65,000	1,800	210,000	210	1,900	11	230	2,400	3,200	1,300

Table 10.—*THERMOELECTRIC POWER (ELECTRIC UTILITY GENERATION) WATER USE, BY REGIONS, IN MILLION GALLONS PER DAY, 1980*

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

WATER-RESOURCES REGION	WITHDRAWALS, BY TYPE OF USE AND SOURCE OF WATER										CONSUMPTIVE USE	
	Cooling of condensers and reactors					Other thermoelectric uses						
	Self supplied					Self supplied						
	Fresh ground water	Surface water		Public supplies	Total	Fresh ground water	Surface water		Public supplies	Total		
		Fresh	Saline				Fresh	Saline			**Fresh**	**Saline**
New England...........	0	2200	7400	0.3	9700	1.2	19	0	190	210	**21**	**0**
Mid-Atlantic..........	6.4	14000	25000	0	40000	100	220	0	7.7	330	**260**	**660**
South Atlantic-Gulf..	73	19000	15000	0.5	34000	15	210	1.5	2.4	230	**270**	**63**
Great Lakes...........	0	27000	0	0.3	27000	30	140	0	2.5	180	**93**	**0**
Ohio..................	34	30000	0	0.8	30000	18	450	0	2.9	470	**320**	**0**
Tennessee.............	0	8800	0	0	8800	0	420	0	0	420	**20**	**0**
Upper Mississippi....	5.1	16000	0	19	16000	8.2	80	0	2.9	91	**290**	**0**
Lower Mississippi....	46	7400	170	22	7600	8.6	280	9.1	0.2	300	**400**	**9.1**
Souris-Red-Rainy.....	0.8	53	0	0	54	0.1	0.2	0	0	0.3	**1.0**	**0**
Missouri Basin.......	38	8100	0	21	8100	9.2	39	0	0	49	**350**	**0**
Arkansas-White-Red...	66	9900	0	540	10000	4.8	24	0	5.4	34	**410**	**0**
Texas-Gulf...........	29	940	5500	1200	7700	1.2	12	0	5.5	19	**360**	**470**
Rio Grande...........	14	2.3	0	4.7	21	0.3	0.2	0	0.1	0.6	**11**	**0**
Upper Colorado.......	0	130	0.7	0	130	0	4.9	0	0.1	5.0	**130**	**0.1**
Lower Colorado.......	41	44	0	0.7	85	3.7	1.5	0	0.4	5.6	**49**	**0.8**
Great Basin..........	4.3	120	5.2	0	130	0.2	0	0	0	0.2	**5.9**	**4.5**
Pacific Northwest....	5.2	23	0	0	29	0.1	0	0	0	0.1	**2.4**	**0**
California...........	890	1100	9200	0	11000	0	0	0	0	0	**61**	**60**
Alaska...............	8.4	22	0	0.5	31	0	0	0	0	0	**0.3**	**0**
Hawaii...............	130	9.0	1200	0	1400	0	0	0	0	0	**0**	**0**
Caribbean............	0	0	1500	0	1500	3.3	0	0	3.2	6.2	**6.2**	**6.0**
Total..............	1,400	150,000	65,000	1,800	210,000	210	1,900	11	230	2,400	3,200	1,300

Hydroelectric Power

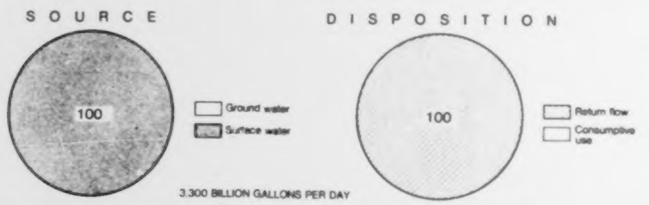
Estimated quantities of water used for hydroelectric power generation may differ because of the manner in which individual estimates are made of the amount of water passed through the plants. Where the water is passed through the plant only one time, good estimates of water use can be obtained. However, where hydroelectric plants have pumped storage facilities and recycle the same water through the plant a number of times, it is difficult to obtain net water use. The magnitude of the effect of pumped storage on water estimates for hydroelectric power generation is not known, but as pumped storage becomes more prevalent, it becomes an important factor in making accurate water-use estimates.

Water used for hydroelectric power generation showed an increasing trend from 1950 to 1975. The trend leveled off from 1975 to 1980, as the amount of water used remained approximately the same, an estimated 3,300 bgd or 3,700 million acre-feet, which is 2.75 times the average annual runoff in the conterminous United States (Langbein and others, 1949). (See tables 11 and 12.) From 1975 to 1980 there was about a 17-percent increase in developed hydroelectric capacity. But during this period utility hydroelectric production decreased 8 percent from 301 billion kWh (kilowatt-hours) to 277 billion kWh, primarily because less streamflow was available in 1980 than in 1975.

Although a very small quantity of water is evaporated (consumptive use) in the generation of hydroelectric power, some depletion of the available water supply will occur as a result of evaporation from reservoirs associated with hydroelectric power generation, repeated reuse of water within a pumped-storage power plant, and the cumulative use that now occurs in successive plants downstream (3,300 bgd used compared with a total surface-water supply of 1,200 bgd). This can be confirmed by the fact that evaporation from reservoirs and regulated lakes, which has been classified as an instream use, contributes to the reduction of available water for all uses. For example, the annual evaporation from the principal reservoirs and regulated lakes in the Western United States is estimated to be 11 bgd (Meyers, 1962, table 6). This amount is equivalent to about 11 percent of consumption by all offstream uses in 1980.

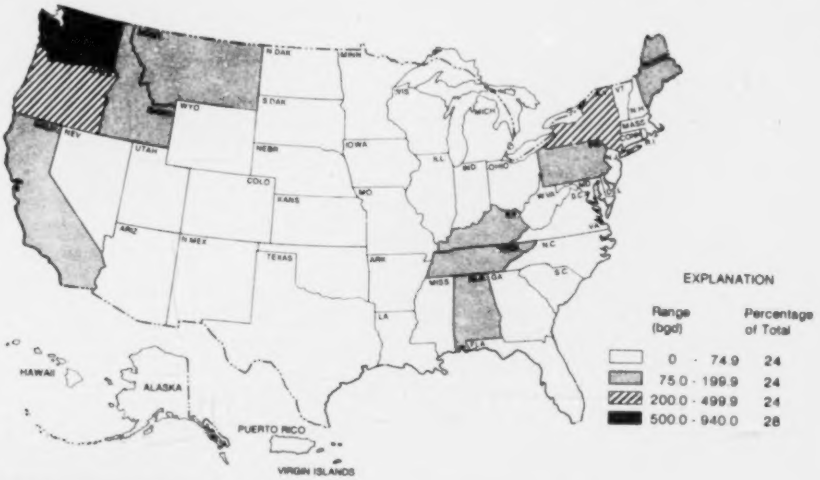
The Pacific Northwest water-resources region was by far the largest user of water for hydroelectric power generation in 1980, accounting for almost one-half the total water used for hydroelectric power in the Nation. Washington and Oregon used more water for hydroelectric power generation than the combined total of all water used for hydroelectric power in the eastern States.

The range in hydroelectric power water use by States and water-resources regions is shown in figure 5. Hydroelectric power water-use data by States are given in table 11, and the same data by water-resources regions are given in table 12. The source of and disposition of water used for hydroelectric power are shown in the chart below.



WATER USED FOR HYDROELECTRIC POWER GENERATION IN THE UNITED STATES, BY SOURCE AND DISPOSITION, 1980, IN PERCENT

A. States



B. Water-resources regions

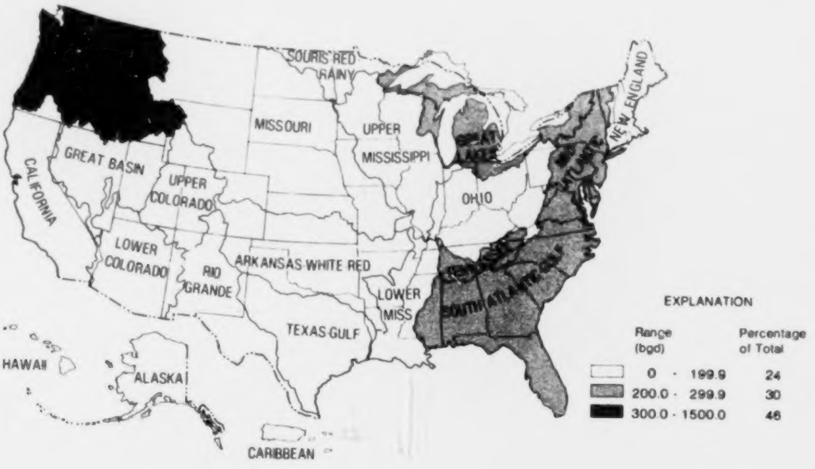


Figure 5. Hydroelectric power water use, by States and water-resources regions, 1980.

Table 11.—*HYDROELECTRIC POWER WATER USE, BY STATES, 1980*

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

STATE	WATER USE	
	MGD	THOUSAND ACRE-FEET PER YEAR
Alabama	170000	190000
Alaska	770	860
Arizona	41000	46000
Arkansas	26000	29000
California	81000	91000
Colorado	5500	6200
Connecticut	4000	4500
Delaware	0	0
D.C.	8.0	9.0
Florida	15000	16000
Georgia	52000	58000
Hawaii	180	200
Idaho	76000	85000
Illinois	26000	29000
Indiana	9500	11000
Iowa	28000	31000
Kansas	570	640
Kentucky	98000	110000
Louisiana	1400	1600
Maine	75000	84000
Maryland	15000	17000
Massachusetts	25000	29000
Michigan	65000	73000
Minnesota	20000	22000
Mississippi	0	0
Missouri	13000	15000
Montana	76000	85000
Nebraska	5400	6100
Nevada	1200	1300
New Hampshire	26000	29000
New Jersey	0	0
New Mexico	430	480
New York	310000	340000
North Carolina	40000	45000
North Dakota	15000	17000
Ohio	380	420
Oklahoma	34000	39000
Oregon	490000	550000
Pennsylvania	81000	90000
Rhode Island	23	26
South Carolina	41000	46000
South Dakota	67000	76000
Tennessee	150000	170000
Texas	7000	7900
Utah	3400	3800
Vermont	14000	16000
Virginia	26000	29000
Washington	940000	1100000
West Virginia	21000	23000
Wisconsin	71000	80000
Wyoming	7200	8100
Puerto Rico	270	300
Virgin Islands	0	0
Total	3,300,000	3,700,000

Table 12.—*HYDROELECTRIC POWER WATER USE, BY REGIONS, 1980*

[Data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

WATER-RESOURCES REGION	WATER USE	
	MGD	THOUSAND ACRE-FEET PER YEAR
New England	140000	150000
Mid-Atlantic	210000	240000
South Atlantic-Gulf	230000	250000
Great Lakes	300000	340000
Ohio	140000	150000
Tennessee	240000	270000
Upper Mississippi	120000	140000
Lower Mississippi	2700	3000
Souris-Red-Rainy	1100	1300
Missouri Basin	150000	160000
Arkansas-White-Red	62000	70000
Texas-Gulf	7700	8700
Rio Grande	1100	1200
Upper Colorado	16000	18000
Lower Colorado	39000	43000
Great Basin	5600	6200
Pacific Northwest	1500000	1700000
California	74000	83000
Alaska	770	860
Hawaii	180	200
Caribbean	270	300
Total	3.300,000	3,700,000

Summary of Offstream and Instream Uses

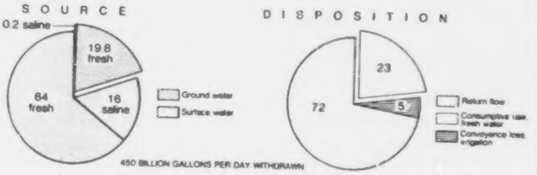
The estimated withdrawal of 450 bgd for all offstream uses (public supply, rural, irrigation, and self-supplied industrial use) in 1980 was about 8 percent greater than the withdrawals estimated for 1975. Ground-water withdrawals accounted for 89 bgd, a 7-percent increase over 1975; of this amount, 88 bgd was fresh water. Surface-water withdrawals accounted for 360 bgd, a 9-percent increase from 1975, of which 71 bgd was saline water. Reclaimed sewage amounted to 0.5 bgd in 1980, an 11-percent decrease from 1975.

Fresh-water consumptive use in 1980 was estimated at 100 bgd, a 7-percent increase from 1975. The percentages of water consumed by the various use categories were nearly the same as in 1970 and 1975. Irrigation water accounted for the largest amount of water consumed, 83 bgd. In addition, conveyance losses associated with irrigation were estimated at 24 bgd. Geographically, 80 percent of the consumptive use was in the Western States, a decrease of 4 percent since 1975 and 6 percent since 1970, whereas, the 20 percent consumed in the Eastern States reflects an increase of 6 percent since 1970. The range in fresh-water consumptive use by States and water-resources regions is shown in figure 8.

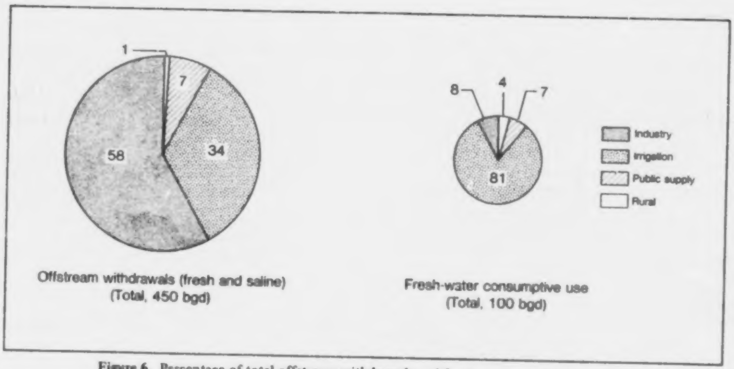
Several tables and illustrations are included in this section to summarize the vast amount of data given in this report. The percentages of water withdrawn and consumed by the four offstream water-use categories are shown in figure 6. The ranges in total offstream withdrawals by States and water-resources regions are shown in figure 7, and the ranges in comsumptive use are shown in figure 8. A comparison of withdrawals from ground- and surface-water sources for both States and water-resources regions is shown in figure 9. The withdrawals of the two largest offstream users, self-supplied industrial and irrigation use, are compared in figure 10.

The per capita withdrawals and consumptive use for the United States and for the eastern and western water-resources regions are given in table 13. The total offstream water use (withdrawals, conveyance losses, and consumptive use) is given by States in table 14 and by water-resources regions in table 15. A summary of withdrawals for the offstream water-use categories is given by States in table 16 and by water-resources regions in table 17. Ground- and surface-water withdrawals are summarized in tables 18 through 21 and also in figure 9.

Total offstream withdrawals by source and disposition are shown in the chart below.



TOTAL OFFSTREAM WATER WITHDRAWALS BY SOURCE AND DISPOSITION, 1980, IN PERCENT



Offstream withdrawals (fresh and saline)
(Total, 450 bgd)

Fresh-water consumptive use
(Total, 100 bgd)

Figure 6. Percentage of total offstream withdrawals and fresh-water consumptive use, by categories of use, 1980.

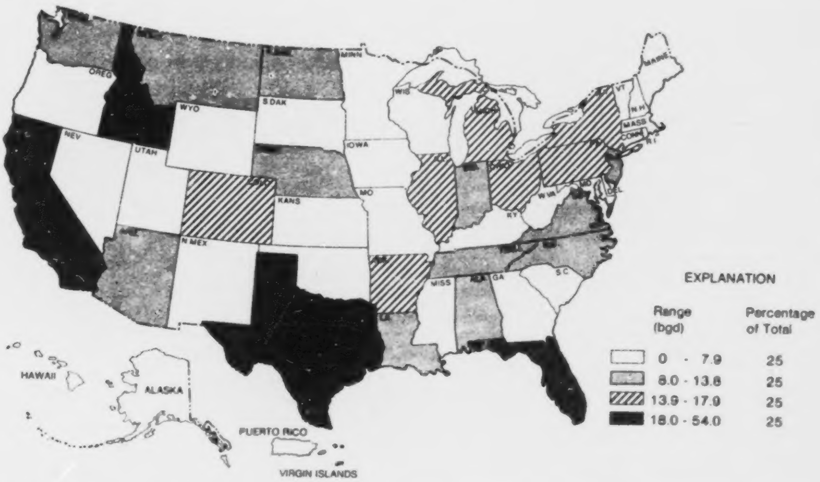
Table 13.—*PER CAPITA WATER WITHDRAWALS AND CONSUMPTIVE USE*
Eastern and western water-resources regions and United States, 1980

[Note: All per capita data calculated from unrounded figures and rounded to two significant figures]

	Conterminous United States water-resources regions		United States (50 States, District of Columbia, Puerto Rico, and Virgin Islands)
	Eastern (9 regions = 31 States)[1]	Western (9 regions = 17 States)[1]	
Population, in millions:			
Total	155.7	69.1	229.6
Served by public supplies	123.5	58.1	186.1
Self supplied (rural)	32.2	11.0	43.5
Per capita water use, in gallons per day:			
Offstream use:			
Total withdrawals[2]	1,600	2,900	2,000
Public supplies:			
All uses[3]	160	230	180
Domestic and public uses and losses[3]	100	150	120
Rural domestic use[4]	73	98	79
Irrigation[2]	82	2,000	660
Self-supplied industrial[2]	1,300	660	1,100
Consumptive fresh-water use[2]	120	1,200	450
Instream use:			
Hydroelectric power[2]	8,900	27,000	14,000
Total offstream and instream use[2]	10,000	30,000	16,000

[1] Approximate boundaries.
[2] Based on total population.
[3] Based on population served by public supplies.
[4] Based on rural population.

A. States



B. Water-resources regions

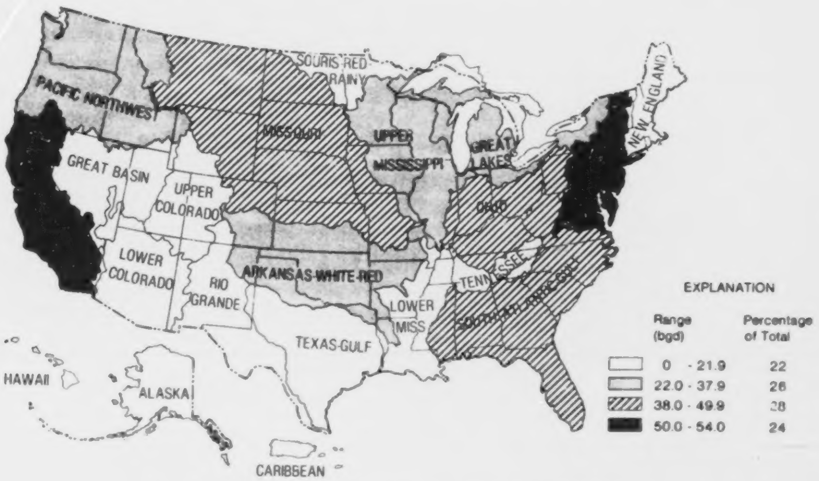
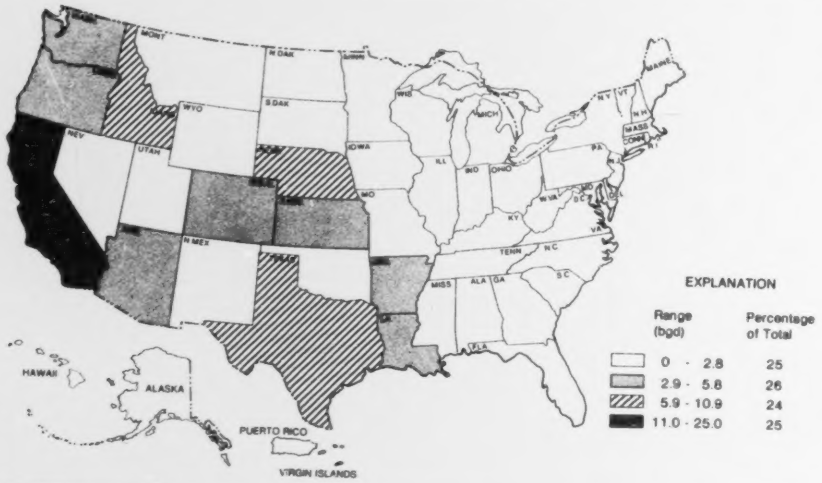


Figure 7. Total offstream water withdrawals, by States and water-resources regions, 1980.

A. States



B. Water-resources regions

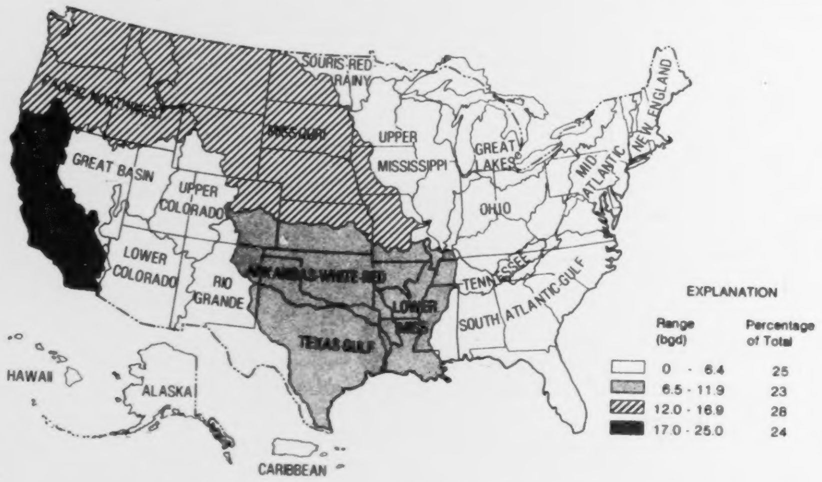


Figure 8. Fresh-water consumptive use, by State and water-resources regions, 1980.

Table 14.—*TOTAL OFFSTREAM WATER USE, BY STATES, IN MILLION GALLONS PER DAY (except as noted), 1980*

[Water-use data generally are rounded to two significant figures, figures may not add to totals because of independent rounding]

STATE	POPULATION, in thousands	PER CAPITA USE, fresh water in gpd	WITHDRAWALS (includes irrigation conveyance losses)										CONVEYANCE LOSSES	CONSUMPTIVE USE, fresh water
			By source and type							Total, excluding reclaimed sewage				
			Ground water			Surface water			Reclaimed sewage					
			Fresh	Saline	Total	Fresh	Saline	Total		Fresh	Saline	Total		
Alabama	3890	2700	350	1.4	350	10000	73	10000	0	11000	75	11000	0	570
Alaska	403	550	49	0	49	170	0	170	0	220	0	220	0	35
Arizona	2718	2900	4200	0	4200	3700	0	3700	5.3	8000	0	8000	900	4500
Arkansas	2290	6800	4000	0	4000	12000	0	12000	0	16000	0	16000	270	3600
California	23669	1900	21000	250	21000	23000	9800	33000	160	44000	10000	54000	5600	25000
Colorado	2889	5400	2800	0	2800	13000	0	13000	0	16000	0	16000	1600	4000
Connecticut	3108	420	140	1.0	140	1200	2400	3600	0	1300	2400	3700	0	160
Delaware	595	230	82	0.3	82	57	1100	1100	0	140	1100	1200	0	11
D.C.	638	530	0.8	0	0.8	340	0	340	0	340	0	340	0	23
Florida	9740	750	3800	42	3800	3600	14000	17000	0	7300	14000	21000	35	2400
Georgia	5464	1200	1200	0	1200	5500	200	5700	0	6700	200	6900	0	1000
Hawaii	965	1400	800	0	800	510	1200	1700	10	1300	1200	2500	300	680
Idaho	944	19000	6300	0	6300	12000	0	12000	13	18000	0	18000	3600	5900
Illinois	11418	1600	930	38	970	17000	0	17000	0	18000	38	18000	0	590
Indiana	5396	2600	1300	0	1300	13000	0	13000	0	14000	0	14000	0	690
Iowa	2913	1500	760	0	760	3500	0	3500	0	4300	0	4300	0	290
Kansas	2363	2800	5600	0	5600	980	0	980	0	6600	0	6600	150	4700
Kentucky	3661	1300	250	0	250	4600	0	4600	0	4800	0	4800	0	290
Louisiana	4199	2900	1800	19	1800	11000	390	11000	0	12000	410	13000	610	3500
Maine	1125	750	80	0	80	770	710	1500	0	850	710	1600	0	53
Maryland	4216	270	150	0	150	970	6600	7600	160	1100	6600	7700	0	100
Massachusetts	5737	430	320	0	320	2100	3500	5600	0	2500	3500	5900	0	90
Michigan	9258	1600	530	420	950	14000	0	14000	30	15000	420	15000	0	460
Minnesota	4061	760	670	0	670	2400	0	2400	0	3100	0	3100	0	450
Mississippi	2521	1100	1500	0	1500	1400	660	2000	0	2900	660	3500	99	710
Missouri	4888	1400	470	0	470	6400	0	6400	0	6900	0	6900	0	670
Montana	786	14000	260	2.1	260	11000	0	11000	0	11000	2.1	11000	2400	2700
Nebraska	1570	7700	7200	0	7200	4900	0	4900	0	12000	0	12000	1900	7600
Nevada	799	4500	710	9.0	720	2900	0	2900	14	3600	9.0	3600	720	1700
New Hampshire	921	420	65	0	65	320	620	940	0	380	620	1000	0	17
New Jersey	7360	390	730	0	730	2100	7500	9600	0	2900	7500	10000	0	360
New Mexico	1300	3000	1800	0.9	1800	2100	0	2100	0	3900	0.9	3900	31	1900
New York	17557	450	780	12	800	7200	8600	16000	0	8000	8600	17000	0	590
North Carolina	5874	1400	770	0	770	7300	42	7300	0	8100	42	8100	0	760
North Dakota	652	2000	120	0.2	120	1200	0	1200	0.4	1300	0.2	1300	120	330
Ohio	10797	1300	980	0	980	13000	0	13000	0	14000	0	14000	0	550
Oklahoma	3025	570	960	95	1100	760	0	760	0	1700	95	1800	53	1000
Oregon	2614	2600	1100	0	1100	5700	0	5700	3.6	6800	0	6800	1700	3200
Pennsylvania	11824	1300	1000	0	1000	15000	93	15000	0	16000	93	16000	0	920
Rhode Island	947	180	37	0	37	140	330	460	0	170	330	500	0.5	15
South Carolina	3119	2000	230	0	230	5900	38	6000	0	6200	38	6200	0	200
South Dakota	695	990	330	3.4	330	360	0	360	1.5	690	3.4	690	12	460
Tennessee	4591	2200	450	0	450	9600	0	9600	0	10000	0	10000	0.6	270
Texas	14013	1000	8000	0	8000	6300	6600	13000	70	14000	6600	21000	200	10000
Utah	1462	3100	1000	4.0	1000	3500	56	3600	0	4500	60	4600	320	2900
Vermont	511	660	45	0	45	290	0	290	0	340	0	340	0	41
Virginia	5346	1000	390	0.2	390	5200	4100	9300	0	5600	4100	9700	3.9	230
Washington	4127	2000	770	0	770	7500	42	7500	0	8200	42	8300	1200	2900
West Virginia	1950	2900	220	0	220	5400	0	5400	0	5600	0	5600	0	200
Wisconsin	4710	1200	610	0	610	5200	0	5200	0	5800	0	5800	0	310
Wyoming	471	11000	540	24	560	4800	0	4800	0	5300	24	5400	1600	2600
Puerto Rico	3400	240	310	5.0	320	500	2400	2900	0	810	2400	3200	30	300
Virgin Islands	100	63	4.0	0	4.0	2.2	32	34	0	6.3	32	38	0	2.1
Total	229,592	1,600	88,000	930	89,000	290,000	71,000	360,000	470	380,000	72,000	450,000	24,000	100,000

Table 15.—*TOTAL OFFSTREAM WATER USE, BY REGIONS, IN MILLION GALLONS PER DAY (except as noted) 1980*

[Water-use data generally are rounded to two significant figures; figures may not add to totals because of independent rounding]

WATER-RESOURCES REGION	POPULATION, in thousands	PER CAPITA USE, fresh water in gpd	WITHDRAWALS (includes irrigation conveyance losses)										CONVEYANCE LOSSES	CONSUMPTIVE USE, fresh water
			By source and type							Total, excluding reclaimed sewage				
			Ground water			Surface water			Reclaimed sewage					
			Fresh	Saline	Total	Fresh	Saline	Total		Fresh	Saline	Total		
New England..........	11941	450	650	1.0	650	4800	7500	12000	0	5400	7500	13000	0.5	360
Mid-Atlantic.........	38881	630	2400	12	2400	22000	28000	50000	160	24000	28000	52000	1.7	1700
South Atlantic-Gulf..	29449	1100	6600	44	6600	27000	15000	42000	0	34000	15000	49000	38	5100
Great Lakes..........	21489	1700	1600	420	2000	36000	0	36000	30	37000	420	38000	0	1300
Ohio.................	21461	1800	2500	24	2500	35000	0	35000	0	38000	24	38000	0.1	1700
Tennessee............	3677	3200	260	0	260	12000	0	12000	0	12000	0	12000	0.2	370
Upper Mississippi....	21083	1100	2600	15	2600	20000	0	20000	0	23000	15	23000	0	1500
Lower Mississippi....	6874	3000	6700	19	6700	14000	390	15000	0	21000	410	21000	960	7100
Souris-Red-Rainy.....	796	280	110	0	110	110	0	110	0.2	220	0	220	5.9	130
Missouri Basin.......	9761	4000	12000	26	12000	27000	0	27000	1.7	39000	26	39000	6000	16000
Arkansas-White-Red...	7900	3000	9400	95	9500	14000	2.0	14000	15	24000	97	24000	360	9600
Texas-Gulf...........	12524	820	5100	0	5100	5200	6600	12000	55	10000	6600	17000	140	6500
Rio Grande...........	1775	2700	1900	0.9	1900	2800	0	2800	0	4700	0.9	4700	290	2400
Upper Colorado.......	548	16000	140	3.5	150	8400	0.7	8400	0.1	8500	4.2	8500	830	2300
Lower Colorado.......	3241	2700	4500	0.2	4500	4200	0	4200	18	8700	0.2	8700	950	4900
Great Basin..........	1782	4200	1600	13	1600	5800	55	5900	4.8	7400	68	7500	1000	3900
Pacific Northwest....	7870	4400	8200	0	8200	26000	42	26000	17	34000	42	34000	6800	12000
California...........	23671	1900	21000	250	21000	23000	9800	33000	160	44000	10000	54000	5800	25000
Alaska...............	403	550	49	0	49	170	0	170	0	220	0	220	0	35
Hawaii...............	965	1400	800	0	800	510	1200	1700	10	1300	1200	2500	300	680
Caribbean............	3500	230	320	5.0	320	500	2500	3000	0	820	2500	3300	30	310
Total............	229,592	1,600	88,000	930	89,000	290,000	71,000	360,000	470	380,000	72,000	450,000	24,000	100,000

Table 16.—SUMMARY OF WATER WITHDRAWALS FOR OFFSTREAM WATER-USE CATEGORIES, BY STATES, IN MILLION GALLONS PER DAY (except as noted), 1980

[Water-use data generally are rounded to two significant figures, population data are rounded to three significant figures; figures may not add to totals because of independent rounding]

STATE	PUBLIC SUPPLY		RURAL USE			IRRIGATION			SELF-SUPPLIED INDUSTRIAL				TOTAL, excluding reclaimed sewage	
									Thermoelectric power		Other uses			
	Population served, in thousands	Withdrawals (mgd)	Domestic use	Livestock use	Domestic and Livestock	Irrigated land, in thousand acres	Thousand acre-feet per year	Million gallons per day	Fresh	Saline	Fresh	Saline	Fresh	Saline
Alabama	2950	620	100	88	190	75	37	33	8500	73	1300	1.6	11000	75
Alaska	286	53	11	0.2	11	0	0	0	30	0	130	0	220	0
Arizona	2440	560	32	12	43	1300	8000	7100	89	0	160	0	8000	0
Arkansas	1700	260	57	61	120	1800	5700	5100	9700	0	510	0	16000	0
California	22300	4100	140	87	220	9700	42000	37000	2000	9200	470	820	44000	10000
Colorado	2540	590	98	110	200	2700	16000	14000	170	0	730	0	16000	0
Connecticut	2500	360	53	2.2	56	17	23	21	610	2400	270	2.0	1300	2400
Delaware	494	79	25	2.0	27	10	7.3	6.5	5.4	670	22	390	140	1100
D.C.	638	210	0	0	0	0	0	0	130	0	1.4	0	360	0
Florida	7790	1400	250	59	310	2000	3400	3000	1900	14000	780	57	7300	14000
Georgia	4180	770	140	28	160	1000	650	580	4400	160	780	42	6700	200
Hawaii	965	200	3.9	5.5	9.4	140	1000	910	140	1200	65	7.0	1300	1200
Idaho	709	160	46	22	68	4000	[illegible]	16000	5.3	0	2200	0	18000	0
Illinois	10700	1800	82	65	150	150	120	110	14000	0	1800	38	18000	38
Indiana	3350	580	120	42	160	65	260	230	9700	0	3100	0	14000	0
Iowa	2120	310	55	130	180	150	62	56	3200	0	550	0	4300	0
Kansas	1740	290	63	81	140	3400	6300	5600	350	0	180	0	6600	0
Kentucky	2450	350	61	39	99	14	5.5	4.9	4100	0	320	0	4800	0
Louisiana	3160	610	56	18	72	740	2500	2200	5900	180	3500	230	12000	410
Maine	473	100	26	1.7	28	11	6.8	6.1	56	700	650	11	850	710
Maryland	3460	490	49	11	60	33	22	20	410	6100	150	500	1100	6600
Massachusetts	5400	800	32	1.2	33	45	21	19	1300	3400	310	64	2500	3500
Michigan	6590	1300	160	22	180	320	240	210	12000	0	1700	420	15000	420
Minnesota	2920	440	120	68	190	460	180	160	1700	0	590	0	3100	0
Mississippi	1980	290	27	21	49	480	1100	980	1100	500	450	160	2900	660
Missouri	4690	730	92	65	160	240	140	130	5500	0	300	0	6900	0
Montana	524	140	60	28	88	2600	12000	11000	180	0	110	2.1	11000	2.1
Nebraska	1240	260	49	120	170	7100	10000	9300	2200	0	64	0	12000	0
Nevada	721	230	11	12	24	850	3500	3100	94	0	140	9.0	3600	9.0
New Hampshire	758	89	9.3	0.8	10	1.8	1.8	1.6	76	620	210	0	380	620
New Jersey	7360	1100	75	3.0	78	75	62	55	910	6500	750	1000	2900	7500
New Mexico	880	210	33	19	52	1400	4000	3600	65	0	6.6	0.9	3900	0.9
New York	15700	2200	130	58	190	56	51	46	4400	8500	1100	130	8000	8600
North Carolina	3110	570	140	39	170	150	150	130	4300	6.4	2900	36	8100	42
North Dakota	505	59	11	21	32	180	310	280	930	0	7.0	0.2	1300	0.2
Ohio	8990	1400	89	40	130	48	5.9	5.3	10000	0	2000	0	14000	0
Oklahoma	2330	300	35	58	93	900	980	870	180	0	270	95	1700	95
Oregon	1200	230	150	26	170	2100	6600	5900	22	0	500	0	6800	0
Pennsylvania	8800	1500	150	61	210	63	180	160	10000	93	3600	0	16000	93
Rhode Island	864	130	4.9	0.2	5.1	4.0	5.6	5.0	0.1	330	35	0.6	170	330
South Carolina	2320	350	65	22	87	73	61	54	5200	7.7	460	30	6200	38
South Dakota	455	76	22	92	110	390	510	460	4.9	0	42	3.4	690	3.4
Tennessee	3720	510	43	42	85	21	14	12	7800	0	1700	0	10000	0
Texas	11400	3800	130	270	400	7700	9500	8400	990	5500	730	1100	14000	6600
Utah	1300	750	29	40	69	1200	3600	3200	64	5.9	460	54	4500	60
Vermont	320	48	20	9.2	29	1.6	1.6	1.4	250	0	15	0	340	0
Virginia	3860	600	150	28	180	41	31	28	4300	4000	470	81	5600	4100
Washington	3300	810	52	6.1	58	1600	7200	6400	1.3	0	990	42	8200	42
West Virginia	1330	180	19	7.6	27	2.4	1.5	1.3	4600	0	830	0	5600	0
Wisconsin	3040	570	72	75	150	240	95	85	4500	0	450	0	5800	0
Wyoming	322	82	9.6	15	25	1800	5400	4900	220	0	170	24	5300	24
Puerto Rico	3200	350	6.0	30	36	75	350	310	3.0	1500	120	930	810	2400
Virgin Islands	64	4.0	2.1	0.1	2.2	0.5	0	0	0	32	0	0	6.3	32
Total	186,000	34,000	3,400	2,200	5,600	58,000	170,000	150,000	150,000	65,000	39,000	6,300	380,000	72,000

Table 17.—*SUMMARY OF WATER WITHDRAWALS FOR OFFSTREAM WATER-USE CATEGORIES, BY REGIONS, IN MILLION GALLONS PER DAY (except as noted), 1980*

[Water-use data generally are rounded to two significant figures, population data are rounded to three significant figures; figures may not add to totals because of independent rounding]

WATER-RESOURCES REGION	PUBLIC SUPPLY		RURAL USE			IRRIGATION			SELF-SUPPLIED INDUSTRIAL				TOTAL, excluding reclaimed sewage	
	Population served, in thousands	With-drawals (mgd)	Domestic use	Live-stock use	Domestic and Livestock	Irrigated land, in thousand acres	Thousand acre-feet per year	Million gallons per day	Thermoelectric power		Other uses			
									Fresh	Saline	Fresh	Saline	Fresh	Saline
New England.........	10000	1500	130	9.2	140	79	59	53	2300	7400	1500	78	5400	7500
Mid-Atlantic........	34100	5400	430	110	550	230	280	250	15000	25000	3400	2100	24000	28000
South Atlantic-Gulf.	21400	3800	720	240	960	3400	6300	3800	19000	15000	5900	330	34000	15000
Great Lakes.........	21500	3900	270	84	350	450	380	340	27000	0	5700	420	37000	420
Ohio................	15300	2200	310	150	470	84	170	150	30000	0	5000	24	38000	24
Tennessee...........	2680	410	61	41	100	14	7.6	6.8	9300	0	2000	0	12000	0
Upper Mississippi...	12600	1900	300	270	570	820	420	380	16000	0	3300	15	23000	15
Lower Mississippi...	5330	920	94	42	140	2900	8700	7700	7700	180	4300	230	21000	410
Souris-Red-Basin....	494	57	23	14	37	120	72	64	54	0	9.3	0	220	0
Missouri Basin......	8090	1400	230	390	630	14000	32000	28000	8200	0	680	26	39000	26
Arkansas-White-Red..	6090	1600	160	240	390	7000	12000	11000	10000	0	840	97	24000	97
Texas-Gulf..........	10100	3000	120	190	310	5200	6200	5500	980	5500	520	1100	10000	6600
Rio Grande..........	1370	320	33	32	65	1400	4800	4300	17	0	16	0.9	4700	0.9
Upper Colorado......	357	120	58	94	150	1300	8400	7500	140	0.7	590	3.5	8500	4.2
Lower Colorado......	2910	720	37	17	54	1400	8500	7600	90	0	250	0.2	8700	0.2
Great Basin.........	1570	810	36	46	82	1900	6600	5900	130	5.2	500	63	7400	68
Pacific Northwest...	5320	1300	270	55	320	7700	33000	29000	29	0	3700	42	34000	42
California..........	22300	4100	140	86	220	10000	42000	38000	2000	9200	480	820	44000	10000
Alaska..............	286	53	11	0.2	11	0	0	0	30	0	130	0	220	0
Hawaii..............	965	200	3.9	5.5	9.4	140	1000	910	140	1200	45	7.0	1300	1200
Caribbean...........	3260	350	8.1	30	38	76	350	310	3.0	1500	120	930	820	2500
Total............	186,000	34,000	3,400	2,200	5,600	58,000	170,000	150,000	150,000	65,000	39,000	6,300	380,000	72,000

Table 18.—*GROUND-WATER WITHDRAWALS FOR OFFSTREAM WATER-USE CATEGORIES, BY STATES, IN MILLION GALLONS PER DAY (except as noted), 1980*

[Water-use data generally are rounded to two significant figures, population data are rounded to three significant figures; figures may not add to totals because of independent rounding]

STATE	PUBLIC SUPPLY		RURAL USE			IRRIGATION			SELF-SUPPLIED INDUSTRIAL			TOTAL, excluding reclaimed sewage	
	Population served, in thousands	With-drawals (mgd)	Domestic use	Livestock use	Domestic and Livestock	Irrigated land, in thousand acres	Thousand acre-feet per year	Million gallons per day	Thermoelectric power	Other uses			
									Fresh	Fresh	Saline	Fresh	Saline
Alabama	1200	160	100	25	130	75	11	9.4	1.5	51	1.4	350	1.4
Alaska	172	23	11	0	11	0	0	0	8.4	6.1	0	49	0
Arizona	1490	300	32	9.8	42	1300	4100	3700	40	140	0	4200	0
Arkansas	880	110	57	22	78	1800	3900	3500	3.1	320	0	4000	0
California	9580	1900	130	36	160	9700	20000	18000	890	420	250	21000	250
Colorado	320	48	35	19	54	2700	3000	2700	9.4	7.1	0	2800	0
Connecticut	521	55	53	0.4	54	17	1.8	1.6	0.2	26	1.0	140	1.0
Delaware	254	30	25	2.0	27	10	4.6	4.1	5.4	15	0.3	82	0.3
D.C.	0	0	0	0	0	0	0	0	0	0.8	0	0.8	0
Florida	6800	1200	250	39	290	2000	1800	1600	70	640	42	3800	42
Georgia	1320	230	140	17	150	1000	420	380	4.1	400	0	1200	0
Hawaii	914	180	3.5	5.3	8.8	140	520	460	130	9.1	0	800	0
Idaho	592	150	44	9.3	53	4000	4500	4100	5.3	2100	0	6300	0
Illinois	4050	480	79	49	130	150	110	100	8.4	210	38	930	38
Indiana	1920	300	110	24	130	65	240	210	5.0	640	0	1300	0
Iowa	1600	230	55	100	160	150	55	49	4.0	320	0	760	0
Kansas	903	140	58	35	93	3400	5800	5200	46	140	0	5600	0
Kentucky	375	47	54	1.9	56	14	0.3	0.2	15	130	0	250	0
Louisiana	1850	270	54	12	67	740	1100	990	46	390	19	1800	19
Maine	101	20	26	1.0	27	11	0.2	0.2	1.0	33	0	80	0
Maryland	417	48	49	10	59	33	11	10	3.0	34	0	150	0
Massachusetts	1550	190	32	0.7	32	45	6.1	5.4	0	93	0	320	0
Michigan	1310	220	160	17	180	320	86	77	0	62	420	530	420
Minnesota	1910	230	120	58	180	460	160	140	2.2	120	0	670	0
Mississippi	1800	250	27	9.7	37	480	950	840	17	360	0	1500	0
Missouri	1520	160	68	17	85	240	110	98	16	120	0	470	0
Montana	184	50	60	14	74	2600	120	110	0	32	2.1	260	2.1
Nebraska	961	210	49	93	140	7100	7500	6700	31	58	0	7200	0
Nevada	329	93	11	3.7	14	850	590	530	8.1	63	9.0	710	9.0
New Hampshire	392	43	9.1	0.2	9.3	1.8	0	0	0	13	0	65	0
New Jersey	3420	450	75	2.0	77	75	45	40	5.0	150	0	730	0
New Mexico	798	190	32	9.6	42	1400	1800	1600	11	6.6	0.9	1800	0.9
New York	3510	350	130	37	170	56	24	21	130	120	12	780	12
North Carolina	474	70	140	33	170	150	44	39	0	490	0	770	0
North Dakota	258	26	11	13	24	180	73	65	1.2	2.2	0.2	120	0.2
Ohio	2950	380	80	24	100	48	2.1	1.9	21	470	0	980	0
Oklahoma	662	86	29	8.2	38	900	820	730	7.7	95	95	960	95
Oregon	344	66	130	7.1	140	2100	950	850	0	80	0	1100	0
Pennsylvania	2180	240	150	54	200	63	25	22	6.8	550	0	1000	0
Rhode Island	142	19	4.9	0.1	5.0	4.0	0.6	0.5	0	13	0	37	0
South Carolina	541	78	65	12	77	73	19	17	0.5	57	0	230	0
South Dakota	321	52	21	81	100	390	170	150	2.4	23	3.4	330	3.4
Tennessee	1450	200	43	7.0	50	21	7.2	6.4	0	190	0	450	0
Texas	5030	930	130	120	250	7700	7300	6500	38	320	0	8000	0
Utah	662	380	26	31	57	1200	600	530	0.2	68	4.0	1000	4.0
Vermont	113	17	17	5.7	23	1.6	0.3	0.3	0	5.2	0	45	0
Virginia	707	120	150	2.3	150	41	9.4	8.4	1.2	110	0.2	390	0.2
Washington	2100	300	40	4.1	44	1600	300	260	0	150	0	770	0
West Virginia	411	49	18	1.0	19	2.4	0.1	0.1	0	150	0	220	0
Wisconsin	1620	290	72	72	140	240	92	82	1.2	96	0	610	0
Wyoming	122	27	8.8	3.1	12	1800	420	370	1.1	130	24	540	24
Puerto Rico	669	73	3.0	15	18	75	150	140	3.0	85	5.0	310	5.0
Virgin Islands	32	2.0	2.0	0	2.0	0.5	0	0	0	0	0	4.0	0
Total	73,700	12,000	3,300	1,200	4,400	58,000	68,000	60,000	1,600	10,000	930	88,000	930

Table 19.—*GROUND-WATER WITHDRAWALS FOR OFFSTREAM WATER-USE CATEGORIES, BY REGIONS, IN MILLION GALLONS PER DAY (except as noted), 1980*

[Water-use data generally are rounded to two significant figures, population data are rounded to three significant figures; figures may not add to totals because of independent rounding]

WATER-RESOURCES REGION	PUBLIC SUPPLY		RURAL USE			IRRIGATION			SELF-SUPPLIED INDUSTRIAL			TOTAL, excluding reclaimed sewage	
	Population served, in thousands	With-drawals (mgd)	Domestic use	Live-stock use	Domestic and Livestock	Irrigated land, in thousand acres	Thousand acre-feet per year	Million gallons per day	Thermo-electric power	Other uses			
									Fresh	Fresh	Saline	Fresh	Saline
New England..........	2730	330	130	4.5	140	79	8.7	7.8	1.2	180	1.0	650	1.0
Mid-Atlantic.........	9440	1100	430	79	510	230	110	97	110	580	12	2400	12
South Atlantic-Gulf..	11400	1900	720	130	850	3400	2300	2000	88	1800	44	6600	44
Great Lakes..........	2970	440	270	64	330	450	200	180	30	630	420	1600	420
Ohio.................	5600	730	290	63	360	84	99	88	52	1300	24	2500	24
Tennessee............	727	89	61	12	73	14	3.0	2.7	0	97	0	260	0
Upper Mississippi....	8330	1100	290	220	510	820	390	350	13	650	15	2600	15
Lower Mississippi....	4170	610	96	17	110	2900	5400	4800	54	1000	19	6700	19
Souris-Red-Rainy.....	253	27	23	9.8	33	120	52	46	0.9	4.2	0	110	0
Missouri Basin.......	3360	530	210	270	480	14000	12000	11000	48	380	26	12000	26
Arkansas-White-Red...	2280	320	130	85	210	7000	9500	8400	70	320	95	9400	95
Texas-Gulf...........	4330	800	120	78	200	5200	4300	3900	30	240	0	5100	0
Rio Grande...........	1100	240	33	26	58	1400	1800	1600	15	16	0.9	1900	0.9
Upper Colorado.......	91	23	15	2.4	18	1300	90	81	0	23	3.5	140	3.5
Lower Colorado.......	1710	370	37	12	48	1400	4400	3900	45	160	0.2	4500	0.2
Great Basin..........	800	400	32	34	66	1900	1100	1000	4.5	130	13	1600	13
Pacific Northwest....	3050	530	230	21	250	7700	5700	5100	5.3	2300	0	8200	0
California...........	9610	1900	130	36	170	10000	20000	18000	890	430	250	21000	250
Alaska...............	172	23	11	0	11	0	0	0	8.4	6.1	0	49	0
Hawaii...............	914	180	3.5	5.3	8.8	140	520	460	130	9.1	0	800	0
Caribbean............	701	75	5.0	15	20	76	150	140	3.0	85	5.0	320	5.0
Total............	73,700	12,000	3,300	1,200	4,400	58,000	68,000	60,000	1,600	10,000	930	88,000	930

Table 20.—*SURFACE-WATER WITHDRAWALS FOR OFFSTREAM WATER-USE CATEGORIES, BY STATES, IN MILLION GALLONS PER DAY (except as noted), 1980*

[Water-use data generally are rounded to two significant figures, population data are rounded to three significant figures; figures may not add to totals because of independent rounding]

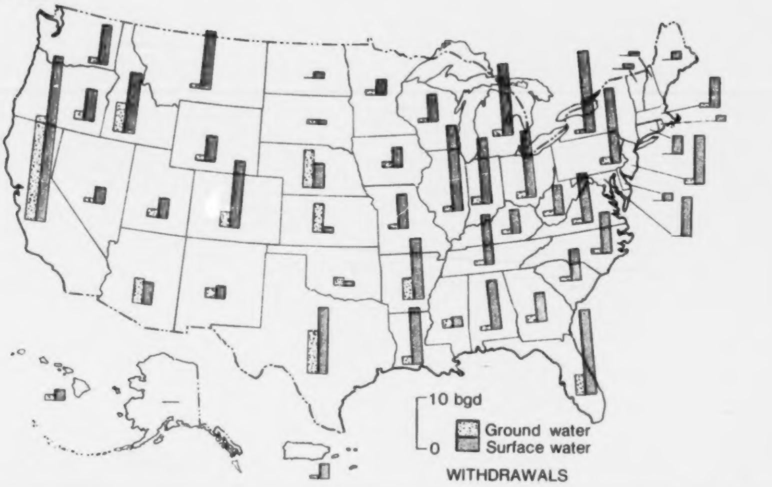
STATE	PUBLIC SUPPLY		RURAL USE			IRRIGATION			SELF-SUPPLIED INDUSTRIAL				TOTAL, excluding reclaimed sewage	
	Population served, in thousands	Withdrawals (mgd)	Domestic use	Livestock use	Domestic and Livestock	Irrigated land, in thousand acres	Thousand acre-feet per year	Million gallons per day	Thermoelectric power		Other uses			
									Fresh	Saline	Fresh	Saline	Fresh	Saline
Alabama...........	1740	460	0	63	63	75	27	24	8500	73	1200	0.2	10000	73
Alaska............	113	30	0.1	0.1	0.3	0	0	0	22	0	120	0	170	0
Arizona...........	945	260	0	1.8	1.8	1300	3800	3400	49	0	20	0	3700	0
Arkansas..........	816	150	0	39	39	1800	1800	1600	9700	0	190	0	12000	0
California........	12700	2200	9.5	51	60	9700	22000	19000	1100	9200	45	560	23000	9800
Colorado..........	2220	540	62	86	150	2700	12000	11000	160	0	730	0	13000	0
Connecticut.......	1980	300	0	1.8	1.8	17	21	19	610	2400	250	1.0	1200	2400
Delaware..........	240	48	0	0	0	10	2.7	2.4	0	670	6.2	390	57	1100
D.C...............	638	210	0	0	0	0	0	0	130	0	0.6	0	340	0
Florida...........	991	180	0.1	20	20	2000	1600	1400	1800	14000	140	15	3600	14000
Georgia...........	2860	540	0	11	11	1000	230	200	4400	160	380	42	5500	200
Hawaii............	51	15	0.4	0.2	0.6	140	500	450	9.0	1200	36	7.0	510	1200
Idaho.............	117	16	2.0	13	15	4000	13000	12000	0	0	120	0	12000	0
Illinois..........	6690	1300	3.6	16	20	150	5.9	5.3	14000	0	1600	0	17000	0
Indiana...........	1430	280	5.6	19	24	65	24	21	9700	0	2500	0	13000	0
Iowa..............	528	84	0.2	25	25	150	7.5	6.7	3200	0	230	0	3500	0
Kansas............	832	150	4.3	46	50	3400	490	440	300	0	41	0	980	0
Kentucky..........	2080	310	6.3	37	43	14	5.2	4.7	4000	0	190	0	4600	0
Louisiana.........	1310	340	0	5.2	5.2	740	1400	1300	5800	180	3100	210	11000	390
Maine.............	372	85	0.5	0.7	1.2	11	6.6	5.9	55	700	620	11	770	710
Maryland..........	3040	440	0	0.5	0.5	33	11	9.4	400	6100	120	500	970	6600
Massachusetts.....	3850	610	0	0.5	0.5	45	15	14	1300	3400	220	64	2100	3500
Michigan..........	5280	1000	0	5.0	5.0	320	120	110	12000	0	1600	0	14000	0
Minnesota.........	1010	210	0	10	10	460	20	18	1700	0	470	0	2400	0
Mississippi.......	182	42	0	12	12	480	150	130	1100	500	97	160	1400	660
Missouri..........	3160	570	24	48	72	240	33	30	5500	0	190	0	6400	0
Montana...........	339	93	0	14	14	2600	12000	10000	180	0	76	0	11000	0
Nebraska..........	276	56	0	23	23	7100	2900	2600	2200	0	6.3	0	4900	0
Nevada............	392	140	0.7	8.5	9.2	850	2900	2600	86	0	74	0	2900	0
New Hampshire.....	366	46	0.2	0.5	0.8	1.8	1.8	1.6	74	620	200	0	320	620
New Jersey........	3940	620	0	1.0	1.0	75	17	15	910	6500	600	1000	2100	7500
New Mexico........	82	21	1.1	9.6	11	1400	2200	2000	54	0	0.1	0	2100	0
New York..........	12100	1900	0	20	20	56	28	25	4300	8500	980	120	7200	8600
North Carolina....	2640	500	0	5.6	5.6	150	100	93	4300	6.4	2400	36	7300	42
North Dakota......	247	33	0.2	8.2	8.4	180	240	210	920	0	4.7	0	1200	0
Ohio..............	6040	1100	8.8	16	25	48	3.8	3.4	10000	0	1500	0	13000	0
Oklahoma..........	1670	220	5.2	50	55	900	160	140	170	0	170	0	760	0
Oregon............	851	160	19	19	38	2100	5700	5000	22	0	420	0	5700	0
Pennsylvania......	6620	1300	0	7.0	7.0	63	160	140	10000	93	3100	0	15000	93
Rhode Island......	723	110	0	0.1	0.1	4.0	5.1	4.5	0.1	330	23	0.6	140	330
South Carolina....	1780	270	0.2	10	10	73	42	37	5200	7.7	400	30	5900	38
South Dakota......	134	24	1.4	11	12	390	340	310	2.5	0	19	0	360	0
Tennessee.........	2270	310	0	35	35	21	6.8	6.1	7800	0	1500	0	9600	0
Texas.............	6360	2900	0	150	150	7700	2100	1900	960	5500	410	1100	6300	6600
Utah..............	634	370	3.3	9.0	12	1200	3000	2700	64	5.9	390	50	3500	56
Vermont...........	207	31	2.6	3.5	6.1	1.6	1.3	1.2	250	0	9.6	0	290	0
Virginia..........	3160	480	0.1	26	26	41	22	19	4300	4000	360	81	5200	4100
Washington........	1200	510	11	2.0	13	1600	6900	6100	1.3	0	830	42	7500	42
West Virginia.....	921	130	1.3	6.6	7.9	2.4	1.4	1.2	4600	0	680	0	5400	0
Wisconsin.........	1420	280	0	3.0	3.0	240	3.4	3.0	4500	0	350	0	5200	0
Wyoming...........	200	55	0.8	12	13	1800	5000	4500	220	0	44	0	4800	0
Puerto Rico.......	2530	280	3.0	15	18	75	200	180	0	1500	30	920	500	2400
Virgin Islands....	32	2.0	0.1	0.1	0.2	0.5	0	0	0	32	0	0	2.2	32
Total..........	112,000	22,000	180	980	1,200	58,000	100,000	90,000	150,000	65,000	29,000	5,400	290,000	71,000

Table 21.—*SURFACE-WATER WITHDRAWALS FOR OFFSTREAM WATER-USE CATEGORIES, BY REGIONS, IN MILLION GALLONS PER DAY (except as noted), 1980*

[Water-use data generally are rounded to two significant figures, population data are rounded to three significant figures; figures may not add to totals because of independent rounding]

WATER-RESOURCES REGION	PUBLIC SUPPLY		RURAL USE			IRRIGATION			SELF-SUPPLIED INDUSTRIAL				TOTAL, excluding reclaimed sewage	
	Population served, in thousands	Withdrawals (mgd)	Domestic use	Livestock use	Domestic and Livestock	Irrigated land, in thousand acres	Thousand acre-feet per year	Million gallons per day	Thermoelectric power		Other uses			
									Fresh	Saline	Fresh	Saline	Fresh	Saline
New England.........	7310	1200	1.1	4.7	5.8	79	50	45	2300	7400	1300	77	4800	7500
Mid-Atlantic........	24600	4300	2.4	32	35	230	170	150	15000	25000	2900	2100	22000	28000
South Atlantic-Gulf.	10000	1900	0.4	110	110	3400	2000	1800	19000	15000	4100	280	27000	15000
Great Lakes.........	18600	3500	2.9	20	23	450	140	120	27000	0	5100	0	36000	0
Ohio................	9710	1500	21	90	110	84	68	60	30000	0	3700	0	35000	0
Tennessee...........	1950	320	0	29	29	14	4.7	4.1	9300	0	2000	0	12000	0
Upper Mississippi...	4240	820	10	51	61	820	32	29	16000	0	2600	0	20000	0
Lower Mississippi...	1170	310	0.5	25	25	2900	3200	2900	7700	180	3200	210	14000	390
Souris-Red-Basin....	241	30	0	3.8	3.8	120	20	18	53	0	5.1	0	110	0
Missouri Basin......	4730	850	22	120	150	14000	20000	18000	8100	0	300	0	27000	0
Arkansas-White-Red..	3810	1200	25	150	180	7000	2700	2400	9900	0	530	2.0	14000	2.0
Texas-Gulf..........	5810	2200	0	120	120	5200	1800	1600	950	5500	280	1100	5200	6600
Rio Grande..........	268	74	0.7	6.0	6.7	1400	3000	2700	2.5	0	0.5	0	2800	0
Upper Colorado......	266	100	43	91	130	1300	8300	7400	140	0.7	560	0	8400	0.7
Lower Colorado......	1200	350	0.1	5.2	5.4	1400	4200	3700	45	0	86	0	4200	0
Great Basin.........	769	410	3.8	12	16	1900	5500	4900	120	5.2	370	50	5800	55
Pacific Northwest...	2260	730	32	34	66	7700	27000	24000	23	0	1400	42	26000	42
California..........	12700	2200	9.4	50	60	10000	[illegible]	20000	1100	9200	58	560	23000	9800
Alaska..............	113	30	0.1	0.1	0.3	0	0	0	22	0	120	0	170	0
Hawaii..............	51	15	0.4	0.2	0.6	140	500	450	9.0	1200	36	7.0	510	1200
Caribbean...........	2560	280	3.1	15	18	76	200	180	0	1500	30	920	500	2500
Total...........	112,000	22,000	180	980	1,200	58,000	100,000	90,000	150,000	65,000	29,000	5,400	290,000	71,000

A. States



B. Water-resources regions

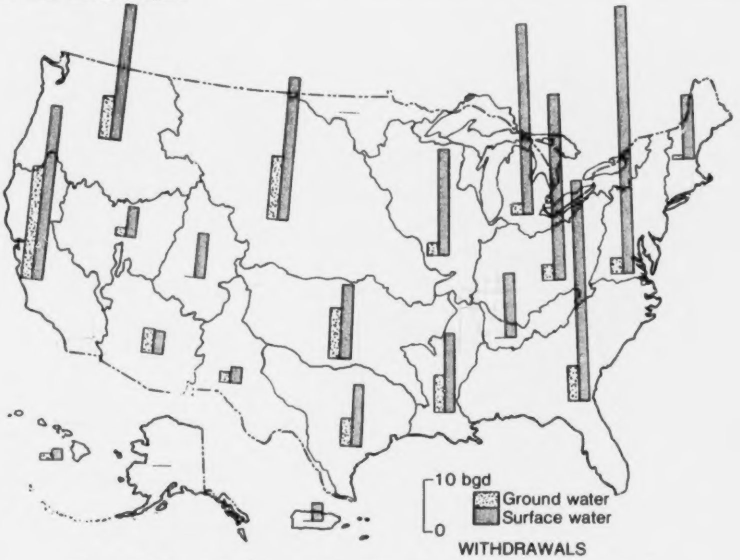
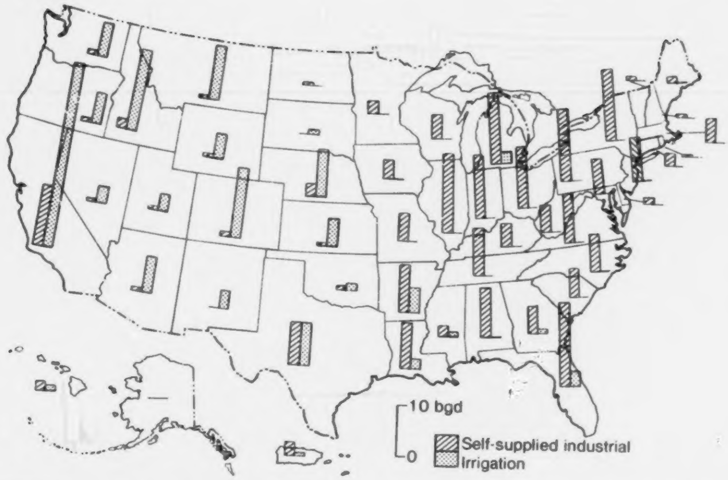


Figure 9. Withdrawals for offstream use from ground- and surface-water sources, by States and water-resources regions, 1980.

A. States



B. Water-resources regions

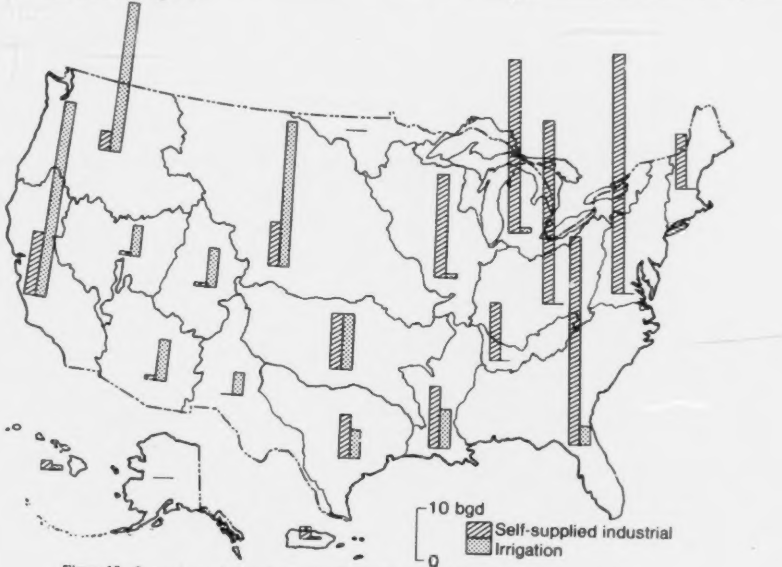


Figure 10. Comparison of withdrawals for self-supplied industrial use and irrigation use, by States and water-resources regions, 1980.

TRENDS IN WATER USE, 1950-1980

Water use for public supply, rural needs, irrigation, industry, and hydroelectric power generation has increased steadily from 1950 to 1980. This trend is shown graphically in figures 11 through 13. Data in table 22, which is a summary of estimated water use—offstream withdrawals, source of withdrawals, consumptive use, and instream use (hydroelectric power)—at 5-year intervals for the period 1950–1980, also confirm this trend. Table 22 also shows the percentage increase or decrease for the various categories of water use and sources of supply for the periods 1970–1975 and 1975–1980.

Trends established over the period 1950 to 1975 did not change significantly during the 1975–1980 period. For most categories of use, the general slackening in the rate of increase that was observed from 1970 to 1975 is again detectable for the 1975 to 1980 period. There are two exception to this trend: public supply and rural withdrawals increased 15 and 14 percent, respectively, compared to corresponding increases of 8 and 10 percent from 1970 to 1975. Part of the increase for public supply is due to the fact that nearly 2 bgd of water previously identified as self-supplied industrial withdrawals was actually public-supplied water, and it is now identified in the public-supply category. The increase in rural withdrawals resulted from an increase in the population being served by self-supplied systems and an increase in per capita use. This per-capita-use increase reflects the application of more realistic estimating techniques, which indicate that previous estimates were probably too low.

Irrigation water use declined from 1955 to 1960, when there was a decrease in the amount of surface water used, but irrigation water use has continued to increase since 1960. The amount of surface water used for irrigation increased 7.1 percent from 1975 to 1980—nearly double the 3.7 percent increase from 1970 to 1975. In contrast, the amount of ground water used for irrigation has increased steadily since 1950; however, the increase from 1975 to 1980 was only 5 percent compared to 27 percent from 1970 to 1975. The average amount of water required per acre for irrigation in 1980 (2.9 acre-ft per acre) was the same as in 1975. Although the acreage irrigated in 1980 was about 7 percent greater than in 1975, it was less than the 9-percent increase that took place from 1970 to 1975 and the 13-percent increase that took place from 1960 to 1965 and from 1965 to 1970.

More water continues to be withdrawn for industrial use than for any other category even though the rate of increase in water withdrawals for thermoelectric power continued to decline—a 33-percent increase from 1965 to 1970, an 18-percent increase from 1970 to 1975, and a 9-percent increase from 1975 to 1980. Withdrawals for other industrial uses remained about the same in 1970, 1975, and 1980.

Water used for hydroelectric power generation had been increasing steadily from 1950 to 1975, but in 1980 hydroelectric power water use was approximately the same as in 1975, compared to a 21-percent increase between 1970 and 1975.

A shift in the source of total withdrawals also is shown by table 22, which indicates that the withdrawal of fresh surface water increased by 10 percent between 1975 and 1980, compared to a 5-percent increase between 1970 and 1975. Fresh ground water and saline surface water, which showed substantial increases from 1970 to 1975 (22 and 31 percent respectively) only increased 7 and 2 percent, respectively, from 1975 to 1980. The slowdown in the rate of increase in total withdrawals, 8-percent increase between 1975 and 1980, more closely follows the rate of increase in total population of 6 percent during the same period. This is in contrast to the rate of increase in total withdrawals during the period 1970–1975, which was more than double the rate of population

Table 22.—*SUMMARY OF ESTIMATED WATER USE IN THE UNITED STATES, IN BILLION GALLONS PER DAY, AT 5-YEAR INTERVALS, 1950–80*

[Data for 1950–75 adapted from MacKichan (1951, 1957), MacKichan and Kammerer (1961), Murray (1968), and Murray and Reeves (1972, 1977). The data generally are rounded to two significant figures; however, the percentage changes are calculated from unrounded numbers]

	Estimated water use in billion gallons per day							Percentage increase (+) or decrease (–)	
	1950[1]	1955[1]	1960[2]	1965[2]	1970[3]	1975[4]	1980[4]	1970–75	1975–80
Population, in millions	150.7	164.0	179.3	193.8	205.9	[5]216.4	229.6	+5	+6
Offstream use:									
Total withdrawals	[5]180	240	270	310	370	420	450	+12	+8
Public supply	14	17	21	24	27	29	34	+8	+15
Rural domestic and livestock	3.6	3.6	3.6	4.0	4.5	4.9	5.6	+10	+14
Irrigation	[5]89	110	110	120	130	140	150	+11	+7
Self-supplied industrial:									
Thermoelectric power use	40	72	100	130	170	200	210	+18	+9
Other industrial uses	37	39	38	46	47	45	45	–6	+1
Source of withdrawals:									
Ground water:									
Fresh	34	47	50	60	68	82	88	+22	+7
Saline	([6])	.6	.4	.5	1	1	.9	–6	–5
Surface water:									
Fresh	[5]140	180	190	210	250	260	290	+5	+10
Saline	10	18	31	43	53	69	71	+31	+2
Reclaimed sewage	([6])	.2	[5].6	.7	.5	.5	.5	+2	–11
Consumptive use	([6])	([6])	61	77	[7]87	[7]96	[7]100	+10	+7
Instream use:									
Hydroelectric power	1,100	1,500	2,000	2,300	2,800	3,300	3,300	+21	–2

[1] 48 States and District of Columbia.

[2] 50 States and District of Columbia.

[3] 50 States, District of Columbia, and Puerto Rico.

[4] 50 States, District of Columbia, Puerto Rico, and Virgin Islands.

[5] Corrected from published report.

[6] Data not available.

[7] Fresh water only.

growth. The rate of increase in consumptive use of fresh water has steadily decreased from 13 percent for the period 1965–1970 to 7 percent for the period 1975–1980. The changes shown in table 22 and figures 11–13 can be attributed to several important factors:

1. Demands on the ground-water system influence the pumping lift, flow rate, or quality of the water supply. Each of these factors also influences the cost of water, and make users, especially irrigators, more selective and efficient with their use of ground water.
2. The price of water influences the volume used and encourages efficient use and may determine when the use of reclaimed water and increased reuse are viable alternatives.
3. Availability of water in a particular year, especially streamflow, strongly affects the quantity of water used for irrigation and hydroelectric power development.

Although 1980 estimates of water use were higher than the 1975 estimates for all offstream categories, trends established during the periods 1970 to 1975 and 1975 to 1980 indicate a general slackening in the rate of total withdrawals in comparison to the period 1965 to 1970. Even with the slackening of the rates of water withdrawal and consumptive use, major attention must be given to water-management problems, because in addition to the need for an adequate water supply, water-quality conditions must be suitable if supply and demand are to be in balance. The degree to which the different uses of water degrade the supply vary widely and affect the potential reuse of the return flows.

Projections of future water use are beyond the scope of this report, although the trends established over the past 30 years provide some basis for estimating future water demands. Many other agencies and commissions have made projections of national water use to the year 2000. Notable examples are studies by the Senate Select Committee on National Water Resources (U.S. Congress, 1961), Resources for the Future, Inc. (Wollman and Bonem, 1971), the National Water Commission (1973), and the U.S. Water Resources Council (1968 and 1978). Summaries of these national projections and projections for individual States to the year 2000 are included in a report prepared by the Congressional Research Service (Viessman and DeMoncoda, 1980). The projections vary greatly based on availability of reliable data and different assumptions of future population growth, economic conditions, environmental regulations and energy-resources development. Regardless of which projection proves correct, major attention must be given to water-management problems to ensure that maximum benefits will be obtained from use of the Nation's water resources.

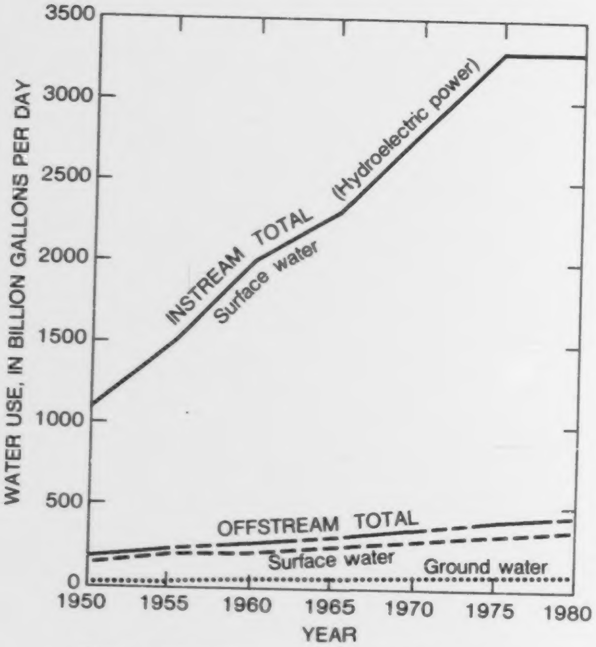


Figure 11. Trends in offstream and instream water use, 1950–80.

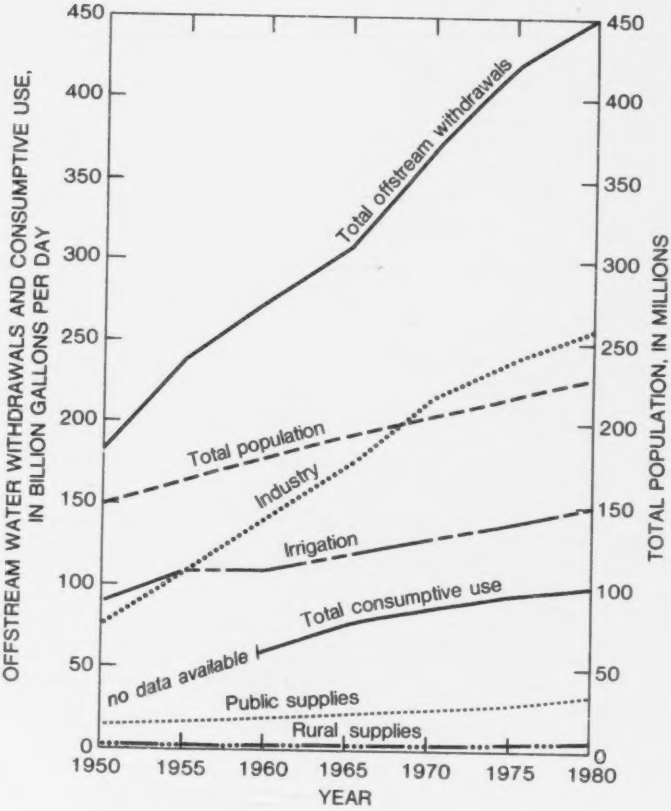


Figure 12. Trends in withdrawals, consumptive use, and population, 1950–80.

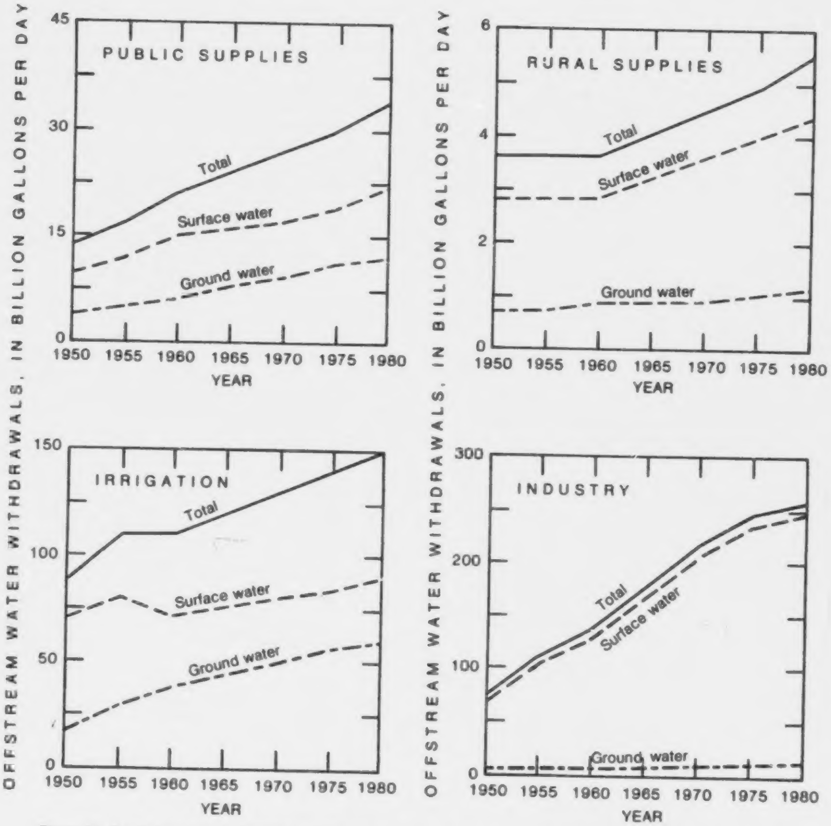


Figure 13. Trends in water withdrawals for public supplies, rural supplies, irrigation, and self-supplied industry, 1950–80.

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The threats to the resource are real,
but not insurmountable

THE FUTURE OF WATER

BY PETER ROGERS

IS THERE A “WATER CRISIS” IN THE UNITED STATES? The impression has certainly been created in recent years that there soon won't be enough water to go around, and that much of what is left is likely to be poisoned. The 1982 report on the state of the environment by The Conservation Foundation, a nonprofit group devoted to the study of environmental policy, describes how excessive consumption of surface water has led to a reliance on groundwater, which has itself been depleted, and also stressed by contamination. In 1981, Robert Harris, a member of the Council on Environmental Quality during the Carter Administration, told a *New York Times* reporter that drinking water is “a significant public health hazard.” An ongoing study conducted by the Environmental Protection Agency lends some support to Harris's charge. By last fall, the EPA had found that the groundwater supplies of 29 percent of the 954 cities in its sample were contaminated, chiefly by toxic wastes that had leached out of landfills.

A review of the popular press is a good way to gauge the conventional view of most questions. The cover of the June issue of *Science 81* showed a rancher, a suburban householder, a miner, and an Indian gathered glumly around a water pump, with the caption: “Rationing the Colorado: Who Gets the Last Drop?” A quick look through back copies of *The New York Times* yields the following: the headline “Efforts to Gain ‘Fishable-Swimmable’ Waters Appear to Falter” (October 12, 1982); Representative Robert Edgar, of Pennsylvania, arguing on the op-ed page, “Is America running out of water? Yes. . . .” (September 23, 1982); the headline “Depletion of Underground Water Formation Imperils Vast Farming Region” (August 11, 1981); and the headline “Toxic Chemicals Loom as Big Threat to the Nation's Supply of Safe Water” (August 13, 1981).

Perhaps the most complete compendium of these concerns to date is Fred Powledge's recent book *Water: The Nature, Uses, and Future of Our Most Precious and Abused Resource*, which is devoted to a description of what Powledge calls “the water crisis.” Powledge writes that “the United States has entered a period of grave emergency in its supply of water,” and that as far as contamination is concerned, “there is little indication that anybody knows what to do about it.” He says, “We are learning that there is no escaping the poisons . . . at least with our current technology.”

Most of what one reads about the pollution of water in every region, and the short supply in some parts of the country, is true. It is not true, however, that nothing can be done. Water's depletion and contamination are not irreversible. We have the technology and management skills to rise to the challenge; only the will to do so has been lacking.

Unfortunately, for many people, the response to news of contamination and shortage—or to the way in which the news is presented—is fear rather than determination. The anxiety arises in part from the fact that since the turn of the century we have been able to take unlimited amounts of clean water for granted. But as recently as the end of the nineteenth century, the mortality and morbidity rates from water-borne diseases were very high. (Because they remain high for the majority of the world's population, the United Nations has designated the 1980s the “International Drinking Water Supply and Sanitation Decade.”) The engineering achievements of the nineteenth century and the early years of the twentieth were, in effect, too successful: as water in short supply and of poor quality became a distant memory, purity and plentifulness began to be assumed rather than systematically safeguarded.

ALTHOUGH THE RESULTS OF OUR POOR STEWARDSHIP are not beyond repair, they should not be minimized. Of these, contamination is by far the most notorious. In 1974, the Safe Drinking Water Act, which Congress passed largely in response to the efforts of environmentalist groups, forced many communities, often for the first time, to search for chemical contaminants in their water supplies, as well as for the traditionally monitored biological sources of pollution. People have been quite surprised by the exotic toxic chemicals that were

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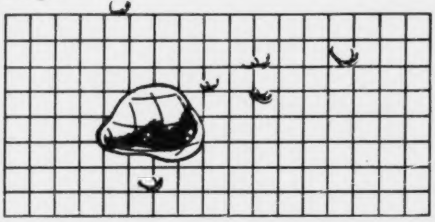
found, and are still being found. Disclosures of the reckless disposal of toxic wastes, which, by leaching into the earth, can contaminate groundwater as well as soil, have not inspired confidence in either government or industry, and the addition of Times Beach, Missouri, to a long roster of contaminated sites has led many people to question the safety of their own surroundings.

Some contaminants are showing up in water not because they have been recently introduced but because scientists have only recently become able to measure them in small concentrations. Moreover, the science of assessing the amount of contaminants in water is a good deal more precise than the science of assessing the effects of contaminants on human health. Here we find that definitive judgments are extremely difficult to make. Although much work remains to be done to improve these assessments, scientists may never know more about the toxic effects of many chemicals than they do now. Too many variables (what statisticians call "noise")—occupation, personal habits, diet, the presence of environmental insults other than the chemical in question, and so forth—exist in any given geographic area to allow clear linkages of diseases to specific contaminants. This frustration is not likely to diminish significantly with time; it represents an inexorable deficit in scientific understanding.

The public has little tolerance for the ambiguities that complicate statements about contaminated water's effects on health. Confronted with the lack of sure knowledge, many people assume that they are being manipulated for devious reasons. Often, in fact, the suspicion is well founded. Although the uncertainties about toxicity ought to be a warrant for extreme caution in any effort to purify water, they have served also as a refuge for manufacturers and the overseers of landfills, who can cite the uncertainties as a way of understating their liability once contamination is discovered. Under these circumstances, rational debate on how best to protect water is hard to sustain.

Safeguarding water's quantity and quality are two parts of a single enterprise—management—and most of the threats to water in this country stem directly from the fact that it is a common resource that has been managed chiefly in the service of private profit. Believing that water is limitless, we have made it available to industry and agriculture essentially at zero cost, and with few stipulations. Therefore, we should not be surprised or offended by the profligacy with which these users have exploited it. Few corporate officers who look to the bottom line of a financial balance sheet would insist on investing large sums to conserve or clean up a resource for which their companies did not have to pay much in the first place.

To worsen the consequences of this fundamental error, the country's shortsighted and rudimentary control of the environment makes it inevitable that the regulators will trail behind those regulated. Even as we restrict the permissible levels of some contaminants we discover others, and must set regulations on those as well, in a never-ending game of catch-up. Similarly, as we undertake large and costly engineering projects to transfer water to farms and factories in regions where it is dwindling, we ensure that the practices that have led to a supply's depletion will persist. Both these obstacles are chiefly matters of policy, however, and policy—unlike the laws of nature—can be changed.



POOR PLANNING IS PARTICULARLY OBVIOUS IN THE country's efforts to deal with chemical wastes, which are a chief source of water's contamination. Although a variety of treatment methods have been developed to make hazardous wastes safe, most wastes have been either stored untreated or indiscriminately dumped. Unfortunately, storage is at best a temporary solution, and an unreliable policy for the future.

The annual tonnage of hazardous wastes produced in the U.S., and other data equally fundamental to any reckoning of the threat to the water supply, are by no means firm. The EPA and other government agencies have not been collecting data for long, and the release of interim numbers to the scientific community and the press has given rise to inconsistent but often-cited figures. For example, a lengthy report on hazardous wastes, which Congress's Office of Technology Assessment (OTA) published in March, cited an estimate by the EPA that between 28 million and 54 million tons of federally regulated hazardous wastes are released in the U.S. each year. The OTA estimates that the total is instead somewhere between 255 million and 275 million tons. The enormous difference between these estimates, which is explained by the OTA's more liberal definition of hazardous wastes, can only complicate the government's efforts to control them. Moreover, within both the OTA's estimate and the EPA's, the margins for error are so wide—at least 20 million tons—that either one alone is a poor basis for policy.

Since no one can say precisely how many tons of hazardous wastes are produced in the U.S. each year, the fact that no sure figures are available on the extent to which chemicals have infiltrated the nation's water should come as no surprise. The United States Geological Survey (USGS) oversees more than 500 stations around the country, which supply regular information on the quality of surface water. These stations do not keep track of all pollutants, however. They do not measure most of the potentially toxic chemicals, and those they do test for elude detection at the low concentrations that would be expected in large volumes of water—concentrations at which the pollutants may nevertheless have significant adverse effects. Thus, although the data the USGS does provide indicate that the country has been able to hold its own with respect to conventional pollutants, such as municipal sewage, the extent of contamination of surface water by unconventional pollutants is barely known.

As for groundwater, *no* systematic monitoring has been undertaken. Instead, we have only incidental evidence, brought to light, by and large, by concerned individuals. In the San Gabriel Valley of California, for example, thirty-nine wells that supplied water to thirteen cities had to be closed in 1980 when they were found to be polluted by high concentrations of trichloroethylene (TCE), an industrial solvent and degreaser. Seven municipal wells and thirty-five private wells near Atlantic City, New Jersey, had been closed by March of 1982, after wastes from a chemical dumpsite were found to have seeped through the sandy soil into groundwater. In Bedford, Massachusetts, four wells providing 80 percent of the town's drinking water were closed in 1978 when they proved to have been contaminated by high concentrations of dioxane and TCE, among other toxic chemicals. By 1979, drinking water in a third of the communities in Massachusetts had been found to be contaminated. In the spring of 1980, the federal Council on Environmental Quality compiled all the reports of groundwater contamination that had been filed at the EPA's regional offices. The results showed that contamination had occurred in at least thirty-four states: in nearly every state east of the Mississippi River, and in the less industrial western states as well.

Although the EPA is conducting tests of drinking-water wells scattered nationwide, it has concentrated chiefly on locating potential sources of contamination. By the end of 1982, the agency had found 80,263 pits, ponds, and lagoons in which industrial, municipal, agricultural, and mining wastes are impounded. Fewer than 10 percent of these sites have been investigated, and of these, only half are being checked on a regular basis to ensure that clean-up is proceeding. In addition to these impoundments, approximately 16.6 million septic tanks routinely disperse their effluent—about 800 billion gallons a year—into the ground. Septic tanks can be a source of chemical as well as biological water pollution, because of the popularity of cleaning fluids sold to flush out sludge. The fluids contain TCE and benzene, which are both known carcinogens. Finally, the 14,000 active municipal landfills, many of which receive industrial wastes as well as the solids from sewage-treatment plants, and the 75,000 active industrial landfills generally are unlined and leach their contents into ground and surface waters.

Given the volume of contaminants released into groundwater, the fact that they have taken so long to show up may seem puzzling. But most of the chemicals are tasteless and colorless, and therefore hard to detect, especially at low—but nevertheless potentially toxic—concentrations. Moreover, water travels through the ground quite slowly; a contaminant may emerge in a well years after it was released from a source even a short distance away.

THE INSIDIOUSNESS OF THE POISONS, THEIR WIDE geographic distribution, and the frequency with which they appear when tests are conducted understandably provoke reactions of panic or despair. Remedies do exist, however. We can insist that manufacturers reduce the amount of waste they produce; we can treat the wastes before disposing of them; we can treat water after it has been polluted; finally, we can restore an entire area after wastes have been discharged. Of course, some combination of these strategies is also possible. It is generally recognized, however, that the cost of cleaning a site after untreated wastes have been dumped is somewhere between ten and a hundred times the cost of treating wastes before disposing of them. The first two options are therefore clearly the best policy.

Any landfill, no matter how well engineered, is likely to leak eventually. Thus, to start with, landfills might be designed in such a way that the leaks would be directed into collectors; even then, they will have to be checked over a much longer period than the thirty years now required by the EPA, because of the extreme corrosiveness and long lives of many of the chemicals contained. Beyond this, technologies for treating wastes are already in place at many manufacturing plants, and the advantages and disadvantages of potential improvements on these should be explored. Segregating the harshest wastes before they are released to a treatment facility (rather than shipping them in mixed form), and altering manufacturing processes to make their by-products more benign and to allow for recycling, appear to be relatively cheap but effective ways to control potential contaminants at their source. Wastes can also be burned. Incineration is not appropriate for all chemicals, however. The most toxic ones must be subjected to extremely high temperatures—an expensive and not yet perfected technology—to keep the gases given off from polluting the air. Dumping hazardous wastes in canisters in the ocean and injecting them in the earth at a depth of 5,000 feet or more—that is, far below easily accessible water tables—are two other possibilities. (Even now, in many coastal cities, the effluent of sewage-treatment plants is freely discharged into the ocean.) Both plans are risky, however, because they bring untreated wastes into direct contact with the environment. Eventually, canisters will leak or break up in the ocean, but, according to proponents of this strategy, the wastes released would be so diluted that their toxicity would be nil. Shifts in ocean currents could defy this theory, though, and wash the wastes in close enough to shore to pose a threat after all. The chemicals could also be ingested by fish and find their way into human diets. As for deep injection wells, wastes could migrate upward along unsuspected fault lines; earthquakes and other unforeseen geophysical phenomena could disturb them too. Chemically breaking down batches of wastes into less toxic forms or decomposing them with bacteria are perhaps the best tactics tried so far, because they ensure that all hazards have been eliminated before a substance is released from a plant.

There is no doubt that, at a price, the country can safely handle its wastes. Prices quoted by nine large firms that treat chemical wastes to bring them up to acceptable safety standards range between $55 and $240 per metric ton. Generously assuming a price of $250 a ton to treat 54 million tons of hazardous wastes a year (the maximum volume estimated by the EPA), the annual cost would be about $13.5 billion. This cost could rise, of course, as more chemicals are analyzed and found dangerous.

Is $13.5 billion, or more, a year a high or a low price to pay for the safe disposal of chemical wastes? There is no easy answer to this question. Consider, however, that this sum represents 2 percent of the annual contribution of manufacturing to the GNP, and 0.4 percent of the GNP as a whole. It should also be kept in mind that this $13.5 billion would not be lost, as payments for imported oil are. Rather, it would create and stimulate a substantial industry—and jobs—in its own right.

A task more arduous than controlling wastes before they assault the environment is cleaning them up after the fact. How a site is cleaned up varies with its proximity to houses and drinking-water supplies, the type of soil, the disposition of groundwater, the specific chemicals dumped, and how they were dumped (in liquid or solid form; in containers or not). Generally, though, problem dumpsites can be handled in one of three basic ways: isolating the site by surrounding it with trenches lined with clay or some other nonporous material, and lining and capping the site itself; diverting the flow of any water through the site, underground or on the surface; removing the wastes and the soil and water they have polluted, decontaminating them by one of the methods cited earlier, and storing them at a controlled landfill.

These options are not uniform in cost. Clearing a contaminated site and treating everything removed from it entails a good deal of money and labor, but once the task is accomplished, little else is required. In contrast, steering water away from a contaminated site is less expensive initially, but purification plants nearly always must be built to ensure that the water is truly safe, and so maintenance costs can be high. Moreover, regular tests for toxicity are essential, no matter how a contaminated site is handled. The EPA's crisis-management strategy has been simply to transfer the contents of a dumpsite, without treating them, to other landfills, which are themselves prone to leaks. Although the EPA's response has the advantage of being fast and relatively cheap in the short term, its ultimate wisdom and cost-effectiveness are dubious.

The obstacles to cleaning up hazardous wastes, like the obstacles to treating them, are economic, and therefore political, rather than technical. The OTA reports that some 15,000 uncontrolled dumpsites are in need of attention. The total cost is estimated at between $10 billion and $40 billion—many times the $1.6 billion that the federal government expects to collect from chemical manufacturers for its environmental "Superfund," established in 1980. If the country chooses to accept the expense, however, the goal is within reach.

ASIDE FROM THE STEPS THE COUNTRY CAN TAKE TO protect water from contamination, there are ways to protect the public from the toxic effects of contaminants already in water. No contaminants appear to have an irreversible effect. What we put in water, we can usually extract—at some cost. Indeed, only the cost and long-term efficacy of the available technologies remain to be established.

The most reliable method that has been developed so far is the granular-activated-carbon (GAC) filter—essentially ground-up charcoal. (Other filter mediums, such as synthetic resins, are also being studied.) The filter works by a physical process called "adsorption." Molecular attraction causes the chemicals flushed through a carbon filter to adsorb, or stick, to the carbon's surface. Once the grains of carbon are covered completely, they are either restored by being subjected to a high temperature, which drives off the chemicals adsorbed (if the filter is a large one, at a municipal plant), or discarded (if it is small, attached to a household tap). There is little risk involved in the disposal of household filters, because they are small and because, in any case, the molecular bond is extremely strong.

A special advantage of carbon filters for municipal drinking water is their proven ability to trap not only chemical wastes that have infiltrated the system from outside but also unwanted chemical by-products of chlorination. The great reduction in water-borne diseases in the U.S. has been sustained by chlorine, which rids water of harmful bacteria. It turns out, however, that chlorine reacts with natural as well as man-made chemicals in water to create a family of chemicals known as trihalomethanes, one of whose members is chloroform, which has been shown to cause cancer in animals. Flushing water that has been disinfected with chlorine through a carbon filter at the end of the treatment cycle can efficiently remove trihalomethanes and any other hazardous organic chemicals present, according to a report released in 1980 by the National Academy of Sciences. The report cautions that further study is needed to make sure that potentially toxic chemical reactions do not occur on the carbon and that no micro-organisms build up in the filters, but it concludes that there is already "ample evidence for the effectiveness of GAC," and advocates the filter for municipal supplies threatened by contamination.

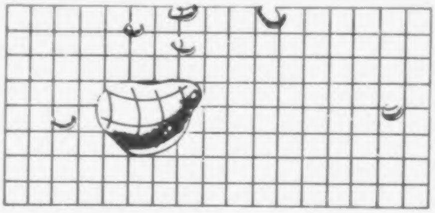
In 1978, the EPA proposed carbon filters as the option of choice for the control of hazardous chemicals in water. Soon after, a group of ninety investor-owned water utilities, the Coalition for Safe Drinking Water, was formed to resist any EPA requirement on that score. Although the coalition expressed doubts about how well the filters would work, their underlying complaint was cost. Studies sponsored by the EPA in response to the coalition's objections have shown that for cities with a million or more residents, the cost of water would rise between 17 and 21 percent. In relative terms, one could argue that the increased cost would be large. But in absolute terms, and considering how cheap water is everywhere in the U.S. at present, the increase would be modest; based on the EPA's figures, for a family of four it would range between $11.81 and $60.25 a year.

Many water utilities have been using carbon filters to control taste and odor and to treat waste water; some have installed them specifically to control toxic chemicals. In Europe, many cities have been using carbon filters for this purpose alone for several years. So far, however, the EPA has not ordered any utilities to install carbon filters. The EPA does require large community systems—representing about 54 percent of the American population—to test for trihalomethanes and other contaminants. People who are concerned that their water might not be safe could ask their utilities for the results. Local health departments may also be able to provide this information, and some may even be willing to accept a sample and test it themselves. Independent tests of domestic water supplies are expensive, but they are the only recourse for the 33 million Americans whose water comes from their own wells.

Fortunately, some of the household-sized carbon filters on the market do a very good job of ridding water of chloroform, trihalomethanes, and other toxic chemicals. *Consumer Reports* reviewed fourteen of them in its February, 1983, issue, and rated five "very good" or "excellent." The three best were Culligan Super Gard SG-2, at $175 ($23 for replacement cartridges); Sears 3464, at $23 ($7.50 for replacement cartridges); and AMF-Cuno AP50T, at $67 ($12 for replacement cartridges). The magazine gave the Sears filter its "best buy" rating, because of its effectiveness and low cost. In Rockaway Township, New Jersey, a dozen houses relying on contaminated well water have been fitted with such small carbon filters, and tests show that the water is up to acceptable safety standards.

An investment in the treatment of contaminated water need not be an endorsement of the uncontrolled release of hazardous substances into the environment. But treating contaminated water can protect the public health for relatively low additional costs while the country goes about cleaning up the mess it has already made.

A good engineering approach is to be very conservative, and to set the highest standards affordable. It is legitimate to ask whether or not the cost of improving the quality of water is too high, but it is also legitimate to ask, compared with what? If the cost is compared with what industry, agriculture, and households now pay for water, it does seem large. But if we compare the cost with the value of water that won't make us sick, it is small. By any standard of comparison, the eventual expense that is likely to result from current policies, which protect water only haphazardly at best, will be enormous.



ALTHOUGH BY NOW IT IS A COMMONPLACE TO SAY that we live in an era of limits, water is still managed in accord with presumptions, laws, and institutions that do not reflect a recognition of these limits. Abel Wolman, professor emeritus of environmental engineering at Johns Hopkins University, and one of the world's foremost experts on water supply, was quoted in *The New York Times* on August 9, 1981, as saying:

> Water is cheaper than dirt. That means there is no orderly design as to when and where to use it. In a vast country such as ours we have never been able to organize a thoughtful, logical national plan, and I am very doubtful we ever will.

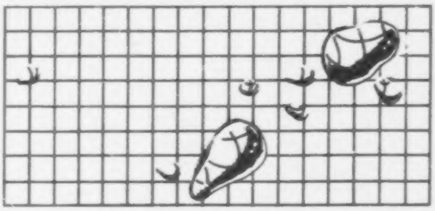
One does not have to be an economist to see the problem of underpricing. Common sense tells us that people waste commodities that they do not value highly, or commodities that, though valued highly, are supplied cheap.

Both in the Southwest, where water shortages are permanent and likely to worsen if present consumption rates continue, and in the Northeast, where shortages are periodic and rarely dire, water prices are extremely low. Indeed, they are lower by half here than they are in Europe. People in Frankfurt, Germany, pay $2.82 per thousand gallons, whereas in Los Angeles, which is significantly more arid than Frankfurt, people pay only $0.60 per thousand gallons. This disparity in prices is reflected in the sharp contrast in rates of consumption between the U.S. and Europe. The average amount of publicly supplied water for all nonagricultural purposes in the U.S. is about 180 gallons per capita per day ("gpcd"), of which 120 gallons go to households and for municipal uses, such as street washing and fire fighting; the rest goes to manufacturing and businesses. Yet in countries with comparable levels of social and economic development, consumption is a fraction of the U.S. rate. The rate in Germany, for example, is 37 gpcd; in Sweden, 54 gpcd; in France, 30 gpcd; and in the United Kingdom, 53 gpcd.

Price differentials alone do not explain the large differences in water consumption in these societies. Consider that in New York City, where water prices are on a par with those elsewhere in the East, the rate of consumption is reported to be 180 gpcd, and supplies to most residential users are unmetered. (As it turns out, the rate of consumption in cities where water *is* metered is roughly half the rate in cities without meters.) In Boston, water prices are also in the range of prices elsewhere in the East, yet the rate of consumption is 233 gpcd—well above the national average. As much as 40 percent of that amount is lost to leaks in the system. Best guesses as to the effect of doubling Boston's 1978 price of $1.18 (now *down*, to $1.00) per thousand gallons suggest that consumption would be reduced at most to 160 gpcd—still four times Frankfurt's rate of 40 gpcd.

Something else in addition to price seems to influence water consumption in the U.S. Americans may be able to recognize, in a theoretical way, the pressures that serve to diminish supply, but they seem unable to keep conservation in mind when devising distribution schemes that borrow from reserves necessary for the future, when confronted with the need to renovate old and wasteful utilities, and when watering lawns and taking showers. Thus, even where water is least plentiful in the U.S., prices rarely reflect supply. Indeed, prices are lowest where water supplies are lowest: $0.53 in El Paso and $0.59 in Albuquerque, compared with $1.78 in Philadelphia or $1.00 in Boston. Moreover, a rise in price does not seem to provoke a commensurate decline in demand. Perhaps American prices are so low that even when they are raised they fail to make an impression on consumers. Can the average homeowner even remember the amount of his last water bill? And how does that expense compare with the cost of an evening's entertainment, or a tank of gas?

However low the price of municipal water in the U.S. appears in comparison with prices in other countries, it is high in comparison with what American farmers pay. The price of agricultural irrigation water in the U.S. ranges between about $0.009 and $0.09 per thousand gallons, and federal subsidies make up the difference between price and cost. The amount of subsidy in the more arid parts of the country is staggering, in fact. In eighteen western federal irrigation projects that the U.S. Department of the Interior studied in 1980, the government was providing between 57 and 97 percent of the costs over the lifetimes of the projects. This works out to an amortized value of between $58 and $1,787 a year for every acre subsidized. Kenneth Frederick, an economist at Resources for the Future, Inc., a nonprofit organization for the study of environmental questions, based in Washington, D.C., wrote in his book *Water for Western Agriculture*, published in 1982, that for all Bureau of Reclamation projects, water subsidies total, on average, at least $500 per acre over the life of a project. Thus, for a 160-acre farm, the subsidy might total $80,000, and in some water-short regions it could be as high as $286,000. Until recently, a 160-acre farm was the largest eligible for federally subsidized water under the 1902 Reclamation Act. An amendment to the act was passed last summer, however, which raised the ceiling to 960 acres for individuals and to 640 acres for corporations. The amendment merely acknowledged the fact that the Bureau of Reclamation had been providing subsidies to farms larger than 160 acres for some time. Simple arithmetic shows that for the largest farms now eligible, the subsidy can rise to between $480,000 and $1,715,510 per farm. Senator Daniel Patrick Moynihan, of New York, who has been persistent in calling for more rational water policies, argued on the Senate floor that the bill represented "all that is wrong with federal involvement in water resources: chaos, arbitrariness, inequity, and waste."



WATER IS NOT LIMITLESS, BUT, CONTRARY TO THE views of alarmists, there is no absolute danger that it will run out. The U.S. as a whole can count on at least fifty years without serious shortages, even at the present wasteful rates of consumption. Extremely difficult choices will have to be made soon in some regions, however, and almost everywhere methods of allocating present supplies and developing new ones need to be more conservative. For water's quantity as for its quality, it is not nature that could prove intractable but policy. The nation has the power to abandon various water-intensive activities in favor of others less demanding on supplies, and the opportunities are numerous enough to make the transition relatively painless.

Annual precipitation in the continental U.S. is about 4,200 billion gallons per day (bgd), on average. Of this amount, 1,400 bgd should be available for all our uses; the rest evaporates. But yearly fluctuations in precipitation further diminish the supply, in ninety-five out of a hundred years, to 675 bgd. The variability of precipitation should be obvious to everyone this year. Rainfall has been well above normal rates in all parts of the country. Notwithstanding the costs that will result from flooding and soil erosion, these rains could bring important benefits: increased supplies in surface reservoirs, an increased volume of groundwater, and increased soil moisture to ease the demand for irrigation. Unfortunately, though, the amount of water that can be carried over from wet years, such as this one, to drier years is quite small, because the capacity of American reservoirs to store it is limited.

According to the U.S. Water Resources Council, the nation's total average daily consumption in 1975—the most recent year for which the council made an estimate—was 106 bgd. Of this amount, fully 83 percent was used in agriculture. Improved irrigation efficiencies could reduce this share substantially. A tremendous asymmetry exists between agriculture, which consumes 83 percent of the nation's water but contributes only 3 percent to the GNP, and manufacturing, which consumes less than 6 percent of the water but contributes 27 percent to the GNP.

Nearly a quarter of the total amount of water consumed in the U.S. is drawn from the ground. Between 1950 and 1975, the demand for groundwater increased 140 percent. Groundwater accounts for half of the irrigation water used in the West, and some appealing features make it a prime target for development. First, a tremendous quantity is stored in American aquifers—underground streams and basins. The Water Resources Council estimated in 1978 that more than a thousand times the amount of water consumed in 1975 lay within 2,500 feet of the surface. Second, groundwater can be used to even out the natural fluctuations in precipitation from year to year. And third, in many areas, groundwater is the only source that remains to be appropriated.

Unfortunately, in addition to those advantages, there are some drawbacks. Extracting water from the ground demands a good deal of energy. Also, the rate of replenishment, or "recharge," is slow—typically less than 10 percent a year, and only slightly faster in years like this, when precipitation is above average. These drawbacks are now becoming critically evident in the West, where, since 1950, development has depended largely on groundwater sources. As a result, annual withdrawals of water in excess of the amount recharged to an aquifer—"overdrafts"—range between 4 and 95 percent in those regions in which farm acreage is increasing most rapidly. In Texas and the Oklahoma High Plains (the site of the vast Ogallala aquifer), the annual overdraft is equivalent to the unregulated flow of the Colorado River—approximately 14 million acre-feet a year. (An acre-foot is the amount of water needed to cover one acre to a depth of one foot.) In all of the western states, the overdrafts exceed 20 billion gallons a day, or 22.4 million acre-feet a year. In the remaining states, overdrafts have been less substantial, rising to one billion gallons. These data show that enough water to irrigate 10.7 million acres is being withdrawn in excess of replenishment from American aquifers. Although overdrafts for short periods do no harm, for the long term they deplete aquifers, and pumping costs rise as a result.

CONSUMPTION HAS MEANING ONLY IN TERMS OF supply, and supply is not always easy to predict, because it is subject to technology, politics, and the economy, as well as to natural constraints. For example, a serious effort has been made during the past fifteen years to modify weather in ways likely to increase precipitation. These techniques—seeding clouds with silver-iodide crystals, for example—are still experimental, but they may prove workable eventually. A problem that engineers have yet to solve is that efforts to increase rainfall in one area might decrease it in another. Then there is desalinization—a technology that has attracted a good deal of publicity and that has been employed successfully in harshly arid parts of the world, such as the Middle East and some islands in the Caribbean. However, desalinization is well enough established now to support the prediction that in the U.S. it will always be too expensive for farming purposes—the only source of demand that could seriously deplete supply here.

Just as human intervention can enhance the water supply, human intervention can diminish it. For example, if the federal government were to impose a ban on overdrafts of groundwater, the supply available to consumers could drop by 25 percent in the country as a whole, and by an even greater percentage in the West. The burning of fossil fuels may have provoked a buildup of carbon dioxide in the atmosphere, and evidence is accumulating that if such a buildup has indeed occurred, the small changes in temperature that will result will lead gradually to large changes in rainfall in the country's mid-latitudes. According to Roger Revelle, a member of a panel on the buildup of carbon dioxide in the atmosphere which was convened by the National Academy of Sciences, if the average air temperature increased by several degrees centigrade at a latitude of about 40° north, a 15 percent decline in precipitation would follow, reducing the flow of the Colorado River system, for example, by half. This could create major agricultural dislocations in Colorado, Utah, and Arizona. Revelle says that a decline in precipitation at this latitude across the U.S. might begin to be felt within the next fifty years. So far, though, the change in the earth's atmosphere and its potential effect on weather are only hypotheses.

The effect of politics and the economy on the country's water supply is easy to demonstrate. A huge federal pork barrel is based in part on the construction of dams and the transfer of water from one basin to another, both of which serve to increase a water supply when it runs short. Between 1965 and 1980, $52 billion was spent on all water-resource projects—inland waterways, ports and harbors, multi-purpose dams, and so forth—by four federal agencies: the U.S. Army Corps of Engineers, the Bureau of Reclamation, the Tennessee Valley Authority, and the Soil Conservation Service.

The Bureau of Reclamation's Central Arizona Project is a good example of how the money is used. This project has been under construction since 1973, and is 38 percent complete. Ultimately, it will divert 1.2 million acre-feet of water a year from the Colorado River basin to the cities of Phoenix and Tucson, and to the agricultural land in between. The water has to be lifted 1,200 feet over a granite reef to a 300-mile-long aqueduct. Most of the water is intended to compensate for the depletion of aquifers by farmers for irrigation; the project will not provide enough water to allow for any expansion in irrigated farmland, or for any further development of cities and industries.

The bureau estimates the project's final cost at between $1.4 billion and $2 billion; estimates made by others are substantially higher. When federal agencies undertake projects like this one, they pay most of the cost; the share borne by the beneficiaries is very small. Moreover, only 6 percent of the $52 billion budget for water projects between 1965 and 1980 was allocated to the Northeast, where 24 percent of American taxpayers reside, and where water systems are generally old—in need of renovation and expansion. The West received 35 percent of the expenditures, though its share of the population is only 17 percent. As a result of this inequity, many congressional representatives of states and districts outside the West have opposed western water-reclamation projects in recent years; indeed, no major package of water-resource projects has been authorized since 1976. A good deal of money remains to be spent, however. According to the General Accounting Office, the cost of the 289 authorized projects still under construction by the Bureau of Reclamation and the Army Corps of Engineers totals $57.4 billion; of this sum, $22 billion had been spent by the end of fiscal year 1981. Another 645 projects have been authorized, with funds yet to be appropriated.

One can object to expensive water projects on the narrow grounds that if they are truly needed, then the beneficiaries should pay for them. But the question of their financing aside, many water projects entail no riders to ensure that the increased supplies will not merely perpetuate a wasteful status quo, in which users who have consumed water indiscriminately can persist in doing so. Federal water projects attract development in regions that have already been developed to a point that strains existing supplies, and they encourage farmers to cling to thirsty crops and inefficient irrigation practices that ought to be abandoned. For example, water supplied by the Bureau of Reclamation to the Grand Valley of Colorado is so highly subsidized that the farmers rely on flood irrigation—they simply cover entire fields with water. Flood irrigation uses up to six times more water than "big wheel" and fixed-sprinkler systems, which are themselves by no means the most advanced and efficient techniques available.

If water and water rights were freely bought and sold, the demand for water would be easier to control; the market would help to establish the most efficient use of the resource. But most water supplies and rights are protected under legal and institutional arrangements that have been worked out over time in accord with objectives other than equity and economic efficiency. The two major legal doctrines—riparian rights and prior appropriation—were designed to secure the land titles of settlers. Riparian rights, which are observed chiefly in water-abundant eastern states, allow the owner of land adjacent to a body of water to make use of the water so long as no inconvenience is caused to his neighbors. Prior appropriation, which is observed in water-short western states, ranks the claims of settlers according to how early their homesteads were established. When a property owner fails to exercise his rights, they lapse. The doctrine is analogous to the pressure on a manager within a corporation to spend all the money budgeted or suffer a cut in funds the following year. Thus, prior appropriation, far from being an incentive for farmers to use less water, is an incentive for them to use as much as they can. In many cases, water rights are attached to parcels of land or specify particular uses. As a result, late arrivals—industries, municipalities, or other farmers—often have trouble acquiring water at any price.

If Indian water rights in the western states are ever enforced, they will reduce substantially the amount of water available to everyone else in those states. The Winters Doctrine, based on the 1908 Supreme Court ruling in *Winters v. United States*, holds that when the federal government claims land for any purpose (specifically, to create an Indian reservation), it at the same time implicitly claims sufficient water to accomplish the purpose for which the land was set aside. At present, Indian water rights remain unquantified, but the Navajos, for example, could legitimately claim as much as a third of the flow of the Colorado. In New Mexico, pending claims by several tribes add up to many times the present allocations of water to all the irrigated farmland in the state.

Water is largely in the hands of the states, and it was only in the nineteenth century—with the passage of the Rivers and Harbors Act of 1826, which established federal control over interstate navigation; the Refuse Act of 1899, which controlled dumping in navigable waters; and the Reclamation Act of 1902, which established a federal role in enhancing water supplies in the West—that the federal government involved itself at all. The state laws are complex, having evolved, much like federal tax laws, over a long period, and there is little chance that a single national code will ever be devised, much less approved, to replace them. In fact, such a code would not even be desirable in this country, where there is so much variation in supply and demand from one region to another. But it is clearly in the interest of the states, perhaps with the guidance of the federal government, to plan equitably in ways that exploit the legal structure rather than conflict with it.

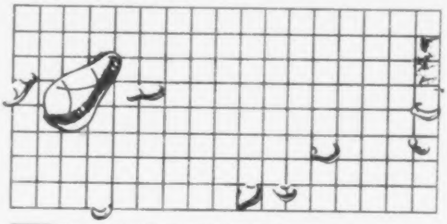
WATER RIGHTS MAY BE UNBREAKABLE, BUT THEY can be bent. For example, a state might offer grants to farmers to offset the cost of adapting farms so that they consume water more efficiently. In exchange, the state would be entitled to the surpluses achieved—water that could then be diverted for municipal and industrial uses, and to increase reserves. Alternatively, since the economic return on water for agriculture is significantly lower than the return on water for manufacuring, industries in arid parts of the country might be enabled, through state intervention, to meet their needs by a mechanism as simple as competitive bidding.

Arizona's Groundwater Management Act—the first comprehensive state law to limit the pumping of groundwater—is a worthy precedent for the thoughtful redistribution of water. It was the severity of groundwater shortages in that state that prompted construction of the Central Arizona Project, but the project will supply only two thirds of the water needed by the year 2000, at current rates of consumption. Thus, the act calls for wells to be registered, and levies fees on the water withdrawn. It calls on farmers to improve irrigation efficiencies, and if these efficiencies are not adequate by the year 2005, it allows the state to buy and retire as much farmland as necessary to restore the natural balance. The act also requires housing developers to secure state certification that a 100-year supply of water is available before construction can proceed.

Harvests need not suffer if farmers use less water than their water rights entitle them to; the agricultural and social optimums rarely coincide, and, given the subsidies, there is no reason why they should. On average, irrigated crops consume only 53 percent of all the water that a farmer withdraws. At farms dependent on surface water, irrigation efficiencies are typically less than 45 percent. At farms dependent on groundwater, the efficiencies are better than 60 percent. The difference is a matter of economics. Irrigation water from surface supplies, which reaches farms through federal or privately managed canal systems, costs a good deal less than groundwater, which farmers must pump themselves. With improved irrigation systems, these efficiencies could rise to between 65 and 75 percent, or higher.

Many farmers—not just those in Colorado's Grand Valley—irrigate by flooding. Alternatives to this practice are "permanent furrow systems," which collect rainwater and surplus irrigation water and channel it to storage ponds for future use; concrete or plastic pipes that carry water underground from the water source to the furrows, reducing the losses to evaporation and seepage incurred by open channels; and "drip irrigation," in which plastic tubes feed small increments of water directly to the roots of each plant. Drip irrigation both inhibits evaporation and allows plants to be fed only as much water as they need; farms in Israel using this method have been reported to achieve efficiencies as high as 95 percent.

Besides reducing total water consumption, farmers might also tap supplies of brackish water, for which there is no competing demand. A rule of thumb in agriculture holds that "if you can drink the water, it's all right to use it for irrigation." Yet some crops—barley and cotton, for example—can flourish with brackish water. Crops less tolerant of salt, such as corn and beans, can also be grown in brackish water if it is supplied in such quantity that the salt is washed past the roots. Running tiled drains under the root zones of the plants also helps to keep salt concentrations low. Brackish water occurs inland as well as near the sea. Thus, adapting drainage systems to accommodate brackish water and growing crops that can thrive on it—leaving sweet water for other uses—are conservation options for farmers everywhere in the U.S., not just those in coastal regions. Brackish water could also be substituted for sweet in air-conditioners, washing machines, and industrial washing and rinsing processes.



THE HOMILY "MOTHER NATURE KNOWS BEST" IS AS true of water as of any other environmental resource. In many arid regions of the U.S., farmers have been able to cultivate crops that are more water-intensive than the resource ultimately can support, because water is cheap. But when a water supply is exploited to the limit of its capacity, nature asserts itself in ways that should force farmers to conserve. As a water table drops, pumping becomes more expensive. For a while, farmers may persist in their withdrawals, choosing to pay for more fuel to run the pumps, or to drill new wells. Eventually, however, the cost will rise higher than farmers can afford, and at that point they will abandon their farms or turn to the crops that can thrive with little or no irrigation, such as sorghum, wheat, and soybeans.

Society can be content with this self-regulating system so long as the irrigated crops lost are not essential to health or economic survival. The system can be hard, however, on the farmers at its mercy, and some form of government subsidy ought to be made available to compensate them at least partially for the cost of converting to different crops. Such compensation is sure to cost much less than the federal projects conceived to increase water supplies artificially.

Does the nation depend on crops irrigated with water from the Ogallala aquifer? Do we need Arizona's cucumbers? The most recent comprehensive study of the question, conducted last year by Kenneth Frederick, shows that we do not. Frederick found that out of a national total of 547 million acres of cropland and pastureland, only about 61 million acres are irrigated. The Center for Agricultural and Rural Development, at Iowa State University, which is the leading research group on American agricultural needs, has predicted that only 32 million irrigated acres will be needed to meet the demand for food and fiber in the U.S. in the year 2000. The Center asserts that even this acreage can be irrigated at lower cost, in both water and dollars, using existing technologies. Clearly, if irrigated acreage can safely decline by half over the next twenty years, the country does not desperately need to water the desert, nor does it need to devote so much of the water it consumes to the task. With a decline in irrigated farmland, and the adoption of more efficient irrigation methods, an enormous amount of water can be saved for drinking and other uses.

Industry has already markedly reduced its demand for water, as a result (unintended) of the Water Pollution Control Act, which Congress passed in 1972. Predictably, economic constraints have proved a powerful motive for change. The act requires industries to treat their own effluents, or to pay others to do so; to cut that cost, firms have found it in their interest to produce less waste. The Water Resources Council estimated in 1978 that by the year 2000, industry will withdraw 62 percent less fresh water than it did in 1975, although its consumption of water will increase by as much as 150 percent. Industries will make up the difference by recycling the water they do withdraw from the nation's supply.

Industries can reduce their demand for fresh water substantially merely by keeping a cleaner house. A large textile plant in São Paulo, Brazil, was able to use 39 percent less water within two years after the city levied a nominal charge for the treatment of its effluent, and the reduction was virtually costless. The plant resorted to such simple practices as shutting off taps when no water was needed and using some wash waters more than once. Where plants are being replaced or renovated, changes in manufacturing processes can also bring about large savings. A new paper-pulping technology developed in Sweden has been demonstrated to use half as much water as conventional processes while nearly doubling productivity: the new process gets ninety-five tons of paper from a hundred tons of wood, as compared with the fifty tons yielded by other means. These savings are realized at a price, however, since the alternative technology requires more fuel and a tenth of the usual manpower.

The nation's demand for energy is another source of stress on the water supply. However, although this demand is sure to rise substantially in the future, the amount of water consumed to generate electricity from steam is not likely to rise commensurately. In fact, steam-power plants will consume about 11 percent *less* water in the year 2000 than they did in 1975, according to the Water Resources Council's last forecast, even though the amount of water they require could be seven times greater. The huge difference between these two figures will be accounted for by improved technologies for cooling water, so that more of it can be recovered. For example, a shift away from evaporative cooling towers to non-evaporative cooling towers, in which condensed water is collected rather than released, cuts the water lost in cooling virtually to zero.

The synthetic-fuels industry, which converts coal and oil shale into more efficient sources of energy, is based chiefly in the West. Although it has been stalled by the buyer's market in oil, its revival will place it in fierce competition for water that is already running short. A coal-gasification plant that can produce 250 million cubic feet of gas a day will require between 3,000 and 15,000 acre-feet of water a year. A coal-liquification plant that can produce 50,000 barrels of fuel a day will require between 5,000 and 10,000 acre-feet of water a year. An oil-shale plant that produces 50,000 barrels of oil a day will require between 2,000 and 9,000 acre-feet of water a year. These are small amounts of water, however, in comparison with agriculture's requirements. A coal-liquification or -gasification plant would use only enough water to irrigate between 1,000 and 5,000 acres, with harvests worth about $250,000. If the same amount of water were used to produce synthetic fuels, it would be worth many times that sum. In 1981, Noel Gollehon and other economists at New Mexico State University studied the likely economic and social consequences of a 40 percent cut (1,245,000 acre-feet) in the water available to agriculture in Montana, Wyoming, Utah, Colorado, Arizona, and New Mexico—states for which synthetic-fuel plants have been proposed. The impact was measured in terms of the loss of income and employment directly related to agriculture and peripheral to it. The $28 million a year and 900 jobs estimated to be lost are not trivial figures. But when these losses are weighed against the income and employment generated by industries producing the equivalent of a million barrels of oil a day, they become a good deal less disturbing.

ALTHOUGH REASONABLE PRICING IS NOT THE ONLY solution to the country's poor stewardship of water, it would have powerful ramifications. No state can be expected to refuse a dam or waterway as long as the federal government promises to foot the bill, even though such schemes may delay its coming to grips with the true sources of a shortage. No consumer in any category can be expected to use less water as long as water bills do not reflect the need. Industry cannot be expected to pay for adequate treatment as long as its failure to do so is met at most by nominal fines and more often by silence. Finally, water utilities cannot be counted on to be careful of chemical contamination, and to take steps to prevent it, as long as the EPA is too timid to insist.

The consumers of water must be made aware of its cost for any effort at conservation to succeed. Consider, for example, the aftermath of the federal Water Pollution Control Act, which provided substantial subsidies for the construction or renovation of municipal sewage systems. By 1982, grants to municipalities totaled about $36 billion. The EPA estimates that by the year 2000, an additional $118 billion will be needed to bring the country's sewerage systems into compliance with the act's standards. Because initially the government agreed to pay 75 percent of all construction costs, but nothing for land or maintenance, it ensured that communities would turn to conventional plants, which are expensive to build but cheap to maintain, and which require little land. By the same token, it ensured that communities would avoid innovative systems, which typically cost little to build and relatively more to maintain, and which require large tracts of land. (Innovative sewage treatments tend to rely on nature itself; they employ liquid sewage to irrigate and fertilize crops or they decompose sewage biologically in oxidation ponds or meadow/marsh systems.) The terms of the grants have since been changed in a way that partially corrects this defect, and compels communities to pay close attention to a project's true cost. In 1985, the government's share will drop to only 55 percent for conventional treatment plants, but it will remain at 75 percent for innovative systems. The grants will still cover only the cost of construction, however, and, as a result, a community's incentive to innovate is still not obvious. According to the EPA, the new grant policy is likely to leave a shortfall of $28 billion—or 24 percent—between the cost of the new or improved systems needed to achieve federal standards and the probable contributions of the federal government and communities to that cost.

The Reagan Administration has effectively eliminated the three federal bodies that were in a position to correct the nation's faulty planning: the Council on Environmental Quality, the Water Resources Council, and the Office of Water Resources Technology. Staffs and budgets were cut back to nearly zero. Even though the Council on Environmental Quality was composed of too many lawyers and too few scientists and engineers, it played an important role in educating the public about the threats to water and the progress toward solutions. The Water Resources Council studied on a continuous basis the adequacy of water supplies in all parts of the country. The Office of Water Resources Technology, in the Department of the Interior, was the major funding agent for studies of water's proper management. The role of all these groups was essentially critical. By consistently pointing out the flaws in how water is being managed, they made an enemy of the EPA, whose administrators did not appreciate negative evaluations of their performance. They also alienated the four agencies holding the purse strings of the government's water projects, and their chief constituencies—farmers, real-estate developers, mining companies, and so on. Last year's amendment to the rules on access to federally subsidized water is only one example of the power of these constituencies to influence the government's control of the resource.

A bill proposed by Representative Edgar, of Pennsylvania, to set up a national commission on groundwater, appears on its face to be a good first step in changing the traditional priorities of water management. Yet, although the bill's intention is worthy enough, such a commission is surely premature. Water policy is already thoroughly fragmented: the Department of the Interior and the USGS have chief jurisdiction over problems of quantity, and the EPA over problems of quality, but no agency is trying to look at the nation's water in all its aspects. Even when it was functioning, the Water Resources Council, which might have studied the interrelationships between supply and purity, and the competing demands of the states, did not do so effectively. Before a commission on groundwater is appointed, there ought to be a commission on *water*. Such a commission should seek ways to resolve the battles between East and West, and to integrate the activities of the various agencies. And it must do so without engaging in the partisan politics in which these agencies are so often embroiled. The American people are owed a careful explanation of the choices they face, both as taxpayers and as consumers of water.

Perhaps, after all, this country can prove Abel Wolman wrong, and devise a "thoughtful, logical national plan" for water. First on the agenda is to compel users to appreciate water's economic value. Prior to the energy crisis, one would not have believed that Americans could curb their appetite for oil. Ten years of rising prices have provoked amazing changes in behavior. The adjustments have not been easy, but many of the ones most feared by politicians and citizens—the charge of $1 or more for a gallon of gas, for example—have come to pass with no real peril to the common good. Higher prices could influence water consumption just as radically, and with less trauma.

Higher prices by themselves will not untangle the snarl of competitive demands for water in regions where it is running short in absolute terms. But higher prices can reveal the true economic value of water, and make the political choices among these demands clearer. Similarly, the public health is not merely in the domain of cost-benefit analyses. Standards of water purity are ideally studied with no consciousness of the financial burdens they would impose. These burdens must then be confronted, however, and borne as part of our commitment to ourselves and to future generations. Compared with the nation's other expenses, these burdens will not be so very large. Insofar as a water crisis exists, it is a crisis of political will. If the country acts wisely, and is willing to pay the price, it can prevent politics from transforming the water crisis of the headlines into a true crisis in the natural world. □

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Summary Report

Water Resources Management

WATER RESOURCES MANAGEMENT:
ISSUES AND POLICY OPTIONS

By

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CALIFORNIA HILLS IN AUGUST

by Dana Gioia

I can imagine someone who found
these fields unbearable, who climbed
the hillside in the heat, cursing the dust,
cracking the brittle weeds underfoot,
wishing a few more trees for shade.

An Easterner especially, who would scorn
the meagreness of summer, the dry
twisted shapes of black elm,
scrub oak, and chaparral -- a landscape
August has already drained of green.

One who would hurry over the clinging
thistle, foxtail, golden poppy,
knowing everything was just a weed,
unable to conceive that these trees
and sparse brown bushes were alive.

And hate the bright stillness of the noon,
without wind, without motion,
the only other living thing
a hawk, hungry for prey, suspended
in the blinding, sunlit blue.

And yet how gentle it seems to someone
raised in a landscape short of rain --
the skyline of a hill broken by no more
trees than one can count, the grass,
the empty sky, the wish for water.

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PART ONE

INTRODUCTION

The environmental and natural resources issues that confront society today cannot be addressed in isolation; they are complex, interrelated and have long-term ramifications. The unmanaged development of groundwater for irrigation, for example, can lead to the creation of water-dependent economies. As groundwater is withdrawn at rates exceeding the safe yield of an aquifer, recoverable quantities of water decline, resulting in higher energy costs for pumping. Depletion of an aquifer can cause land subsidence as porous soils compact or the influx of poor-quality water in response to changes in artesian pressure. This combination of dwindling supply and high energy costs may force farming interests out of business unless alternative sources of water are developed.

Land development can likewise affect the quality and the quantity of water available for use. Construction activities frequently alter the slope and natural vegetative cover of land, thereby reducing its absorption capacity and increasing runoff. Erosion may channel heavy metals from building sites, fertilizers and pesticides from agricultural lands, and sediment from forestry harvesting and road-clearing operations into streams, resulting in water quality degradation. As development activities replace permeable soils with concrete, aquifer recharge zones are eliminated, reducing the volume of groundwater available for withdrawal.

State legislatures will play a dominant role in formulating necessary resource policies. To assist them in their efforts, the National Conference of State Legislatures (NCSL) is conducting a three-year project (1981-1984) to provide state legislatures with information sufficient in scope to help explain the interactive, long-range nature of resource issues, and focused enough to provide clear policy alternatives for addressing current problems. Funding for this project has been provided by the Andrew W. Mellon Foundation and the William & Flora Hewlett Foundation, to whom NCSL is extremely grateful.

This document summarizes NCSL's water resources report entitled, Water Resources Management: Issues and Policy Options, the first in a series of three publications that will study land and renewable resource issues in succeeding years. It emphasizes the policy considerations discussed in the full report. Individual citations are not used in the text of this summary document but appear as part of the reference section at the end of the report. The full report is extensively documented throughout, and may be ordered from the NCSL office in Denver.

PART TWO WATER RESOURCES PROBLEMS AND ISSUES

WATER QUANTITY PROBLEMS AND ISSUES

The two major water quantity problems facing the states are inadequate surface water supply and groundwater overdraft. The two may be directly related, with groundwater depletion often resulting from the need to augment declining surface supplies.

Complicating the nature of water quantity problems is the lack of data necessary for sound policymaking. Policymakers require sufficient data not only on the quantity of water available in surface and underground basins but also on the impacts of different levels of diversion or withdrawal on the flow, safe yield, and quality of water if technical information is to be useful as a management tool.

Data Problems

Because of the interrelated nature of water, land, and renewable resource issues, it becomes imperative that the best available data be used to measure the impacts of one resource activity on another. Data gaps are particularly evident for groundwater and consist of two major types: (1) a lack of basic geologic and hydrologic information concerning the location, physical composition, and water-storage capacity of an aquifer; and (2) the inability to simulate water flows to predict the impacts of groundwater withdrawals on the aquifer, connected surface water, and overlying land. These data gaps exist in every region of the country to some degree and are more critical for deep underground basins than for aquifers closer to the surface (primarily due to the existence of more wells at shallow levels).

To assist in the policymaking process, hydrogeologic data should ideally be placed in a modeling system with the capacity to predict the impacts on groundwater, connecting surface waters, and land of specific levels of pumping. Through their ability to simulate water flows, three-dimensional digital models can achieve these results. A model developed for the Arkansas River Valley in Colorado incorporates aquifer transmissivity, groundwater yield, and hydrogeologic boundaries into the system. It defines ground/surface water relationships and evaluates evapotranspiration losses within the aquifer, and is used to predict changes in groundwater storage and the impacts on surface water supply of groundwater pumping. Changes in Colorado water law have been based on the results of its simulations.

Inadequate Surface Water Supply

Competing uses of water combined with limited natural supply has resulted in actual or potential surface water shortfalls in several regions of the country. Assessments of water availability and use conducted by the U.S. Water Resources Council, U.S. Geological Survey, and Resources for the Future all indicate current or projected problems in regions extending from Texas and the High Plains through the Colorado River Basin and into California, as well as the urban and industrial areas bordering the Great Lakes. Surface water quantity problems are also apparent in isolated portions of the South Atlantic-Gulf (e.g., Florida) and the Mid-Atlantic States (e.g., Delaware River Basin).

Groundwater Overdraft

Groundwater overdraft increasingly is becoming a national problem as sufficient sources of surface water diminish, through either overuse (primarily in the western states) or constraints placed upon use by water-quality degradation (more prevalent in the northeastern and midwestern states). In 1975, approximately 25 percent of all groundwater withdrawals were overdraft. Over one-half of the total overdraft -- 14 million acre feet -- occurred in the six-state High Plains area overlying the Ogallala Aquifer (portions of Nebraska, Kansas, Colorado, Oklahoma, New Mexico, and Texas). Overdraft can result in such serious related resource problems as land subsidence and saltwater intrusion, and in addition to the High Plains states is most evident in California and Arizona, along with portions of the Great Lakes, Lower Mississippi, and South Atlantic-Gulf regions in the East and Midwest.

One of the major concerns with unmanaged groundwater pumping is the impact on connected surface water bodies; overdraft may lead not only to declining groundwater levels but also drawdown of streams. For those aquifers that are not directly tributary to surface water (e.g., deep, confined bedrock aquifers in Colorado), mining of groundwater -- withdrawals in excess of recharge -- may be an explicit state policy. The rationale for such a policy rests on a determination that the underground basin is not connected to another source and little or no natural recharge capacity exists. Withdrawals then may proceed on an amortized basis (i.e., on a schedule that will not exceed an arbitrarily designated life span for the aquifer). If such a policy is chosen, it must be based on sound hydrogeologic data.

Federal Constraints -- Reserved Water Rights

Contributing to the data problem is the uncertainty of the quantity of water available for management because of the unquantified claims of the federal government and Indian tribes. This potentially can be a major problem in those states with large federal landholdings and Indian reservations.

The federal government's claims spring from a series of federal court decisions -- notably Winters v. United States, 207 U.S. 564 (1908); Arizona v. California, 373 U.S. 546 (1963); and United States v. New Mexico, 438 U.S. 696 (1978) -- holding that water rights were reserved by implication when land was set aside for Indian reservations and other national purposes (e.g., national parks and forests). The courts have ruled that sufficient water was reserved to fulfill the purposes of the reservation, even though specific quantities were not claimed at the time the reservation was made. The states have generally accepted the right of the United States to use water on federal lands but have insisted that such rights be inventoried so that all present and potential water rights holders know the status of water available for use, and that any new federal or Indian water rights claims be adjudicated in state courts to provide for a uniform system of determining all water rights within a state.

Case Studies

The following case studies illustrate critical water quantity problems and issues in different states and regions. They have been selected on the basis of the severity of the problem, the interrelationships with other resource issues, and geographic diversity.

Florida. Florida is a relatively water-abundant state, with an average annual rainfall of over 50 inches. Yet because of its warm climate, over three-fourths of that amount returns to the atmosphere through evapotranspiration. The state's flat topography precludes water storage in mountain valleys found in other states, and most of its nearly 8,000 lakes are too small and shallow to store much volume for later use. As a result, the primary source of water for most uses is groundwater and the rainfall that replenishes these underground water formations.

Land development has seriously threatened this primary water source in two ways: (1) overpumping has caused saltwater intrusion as water from the Atlantic Ocean and the Gulf of Mexico responds to changes in pressure gradients and fills the void left by excessive freshwater withdrawals; and (2) the conversion of wetlands and other permeable soils to concrete eliminates valuable groundwater recharge zones, thereby preventing an aquifer from naturally regaining its former water level and accentuating the impact of overwithdrawals.

The destruction of wetlands may also affect the amount of rainfall. By draining wetlands, the quantity of water returning to the atmosphere through evapotranspiration is reduced. This humid, buoyant air might normally assist in the formation of clouds and through condensation fall again as rain. It may also be possible that evapotranspiration from wetlands induces precipitation from weather systems passing over the peninsula. Although the degree of rainfall enhancement attributable to evapotranspiration from wetlands may not be accurately known, the unmanaged conversion of wetlands to other land uses eliminates any potential contribution.

California. California's annual net water demand is approximately 31 million acre feet (an acre foot equals the amount of water necessary to cover one acre of land to a depth of one foot or 326,000 gallons). This demand exceeds the dependable water supply by an average of 2.4 million acre feet (maf) each year. This deficit is made up largely through groundwater mining in the large irrigation areas of the Central and Imperial valleys. Of the nearly 7.5 maf of groundwater withdrawn each year, 2.2 maf -- 30 percent -- is overdraft. Continued overdraft could have serious ramifications (e.g., high energy costs, poor water quality, diminished water supply) for an agricultural economy that depends on groundwater to meet its production needs.

Surface water problems are also apparent in the southern part of the state. Current contracts between southern California water supply agencies -- for both urban and agricultural uses -- and the U.S. Department of the Interior for Colorado River water total 5.4 maf (although actual use is currently 4.7 maf). California's allocation of the Colorado River will be cut back, however, to 4.4 maf in 1985 when the Central Arizona Project begins diverting water from the Colorado River. This 0.3-1.0 maf shortfall will have to be made up through water conservation measures or increased surface water deliveries from the State Water Project (or a combination of both) if existing and planned water needs are to be met without further groundwater depletion. With the defeat of Proposition 9 -- which would have directed the Department of Water Resources to construct the Peripheral Canal (a 43-mile long facility which would have diverted freshwater directly from the Sacramento River around the San Francisco Bay-Delta area to pumping stations for transport south) and would have authorized the construction of several other water development and conservation projects -- on June 8, 1982, other transfer facilities will have to be studied if more effective water conservation and management is not able to make up projected shortages.

High Plains. The High Plains area encompasses portions of six primary states: Nebraska, Kansas, Colorado, Oklahoma, New Mexico, and Texas. It contains 20 percent of the nation's irrigated acreage and accounts for a substantial proportion of the livestock, wheat, corn, sorghum, and cotton produced each year. Irrigated acreage has more than quadrupled in the last 30 years, accompanied by a threefold increase in water withdrawals. More than 90 percent of all water used is taken from the Ogallala Aquifer.

Water storage in the aquifer amounted to roughly 3 billion acre feet in 1977, with over three-fourths of that underlying Nebraska, 9.4 percent in Texas, 8.1 percent in Kansas, and the balance divided among Colorado, New Mexico, and Oklahoma. Continued use of the aquifer at its present pace is projected to result in a 23-percent reduction in storage by the year 2020, with losses in Colorado, New Mexico, Oklahoma, and Texas each amounting to more than 50 percent of storage capacity. New Mexico, Oklahoma, and Texas face the severest problems because while they comprise nearly 50 percent of the irrigated acreage in the six-state region, they have only 12 percent of the remaining water in storage in the Ogallala Aquifer. The long-term ramifications of continued groundwater overdraft may be changes in the type of crops produced as irrigated agriculture gradually turns to dryland farming. This change may affect not only the region's economy, but also the environment by increasing wind erosion of formerly irrigated soil and destruction of wildlife habitat dependent on water.

WATER QUALITY PROBLEMS AND ISSUES

Unlike water quantity problems and issues -- which may be identified only with specific regions of the country to the exclusion of others -- water quality concerns are more pervasive, affecting virtually every region of the country to some degree. The reason is that while supply may be a geographic variable, land activities -- which are the primary causes of pollution -- are similar for, and essential to, growth and development in humid as well as arid areas of the United States. Municipal and industrial discharges (point source pollution) and urban and agricultural runoff (nonpoint source pollution) are potential problems everywhere.

Water Quality Monitoring

The need for adequate data on water quality conditions and trends is essential to devising effective water quality protection policies. The U.S. Environmental Protection Agency (EPA) and the U.S. Geological Survey (USGS) are the primary federal agencies involved in collecting information on the quality of the nation's surface water. Their efforts are combined with those of individual states (which provide EPA with most of its data) and interstate water pollution control agencies. The primary approach used to determine water quality conditions and trends is fixed-station monitoring.

The reliance on fixed-station monitoring to provide data for water quality analysis has been criticized on two fronts: (1) a fixed-station (usually downstream of major pollutant discharges) only measures water quality at a certain end point and is not capable of measuring instream quality or quality upstream; and (2) water quality samples are taken only at fixed intervals, e.g., monthly, quarterly or yearly. Several critics, including the federal General Accounting Office (GAO), have suggested that the emphasis of water quality data gathering should shift away from fixed-station monitoring to conducting intensive special studies of individual stream segments where water quality problems are critical. For special studies to be effective, however, repetition would be required to establish trends in water quality improvement or degradation. Fiscal constraints, especially at the federal level, may preclude implementing monitoring programs that provide reliable data for policymaking.

Groundwater Contamination

Groundwater quality problems exist in parts of every state. While highly urban and industrialized areas in the Northeast and Midwest receive much of the national attention, groundwater contamination is also a major problem in many rural areas, where 95 percent of the population relies upon groundwater to meet domestic needs. Major categories of contamination include industrial landfills, agricultural runoff, and on-lot disposal systems. Water use can also affect groundwater quality; overpumping of wells may lower fresh groundwater levels to a point where changes in pressure cause saltwater intrusion. This problem can occur not only in coastal areas but also in regions where the soil has a high natural mineral content.

The most pervasive -- and potentially most serious groundwater contamination problem because of the health-related impacts -- is leaching of waste materials from solid and hazardous waste landfills. This is a problem in large urban and industrialized states (e.g., California, Florida, Massachusetts, Michigan, New Jersey, New York, Ohio, Pennsylvania) as well as in smaller, more rural states (e.g., Arkansas, Colorado, Maine, Montana, New Hampshire, North Dakota, Tennessee, Vermont). One indicator of where critical groundwater contamination problems may exist is EPA's designation of priority hazardous waste disposal sites to be addressed by "Superfund" monies, a five-year, $1.6-billion federal cleanup effort. An initial list of 114 priority sites was released October 23, 1981 (the final list of 400 sites should be completed in December 1983); 41 states had designated sites, with Florida (16), New Jersey (12), New York (8), Pennsylvania (8), and Minnesota (5) heading the list.

The rural nature of groundwater quality problems can be seen in the number of states with agricultural and on-lot (septic system) waste disposal concerns. Pollution from agricultural activities can be the result of leaching of fertilizers and pesticides into groundwater as well as dissolved salts from irrigation return flows. States experiencing such problems include Arizona, Idaho, Kansas, Nebraska, South Dakota, Texas, Utah, Iowa, Minnesota, Missouri, Ohio, Delaware, New York, Rhode Island, and Virginia. Septic system problems result from overly concentrated waste disposal activities in a limited area and percolation of septic tank cleaning fluids into groundwater. These problems occur in newly urbanized areas and rural communities in every region of the country.

Case Study: Long Island, New York. Nearly three million residents of Nassau and Suffolk counties in New York rely totally on the three aquifers underlying Long Island for their drinking water needs. Yet rapid population increases accompanied by land-disturbing activities and the growing use of chemicals in agriculture and industry have jeopardized this resource. Nitrate and organic chemical contamination have shown up in a number of tests conducted on public water supply and monitoring wells, with the greatest degree of contamination occurring in the shallow Upper Glacial Aquifer.

A special legislative commission has been established to study the water resource needs of Long Island. One of its goals is to identify, protect, and manage critical watershed areas. The commission has submitted legislation -- S. 9178 and A. 11732 -- which would set up special protection areas within a sole source aquifer designated by EPA (Long Island has been designated a sole source aquifer under the federal Safe Drinking Water Act).

Local governments have also been active in seeking to protect the quality of Long Island groundwater. In 1975, the town of Brookhaven rezoned 6,000 acres of the central pine barren area -- a major recharge zone in Suffolk County -- for minimum two-acre residential units in an attempt to lessen the impact of land-disturbing activities and on-lot disposal systems on groundwater quality. Developers challenged this ordinance as a taking of property without compensation. The ordinance was upheld in state and federal courts as meeting legitimate and proper governmental objectives.

Nonpoint Source Pollution

Nonpoint source pollution contributes significantly to water quality degradation, amounting to one-half of the volume of pollutants discharged each year. This form of pollution is diffuse and not as easily traceable to specific sources of discharge as is point source pollution. Nonpoint sources include soil erosion and sedimentation from improper agricultural land practices, urban stormwater runoff, mining operations, forestry practices, and leaching of waste materials into groundwater from solid and hazardous waste landfills.

Unlike solutions to municipal and industrial waste discharge problems -- which are capital-intensive and costly -- nonpoint source problems can be corrected through changes in land management practices at much less cost. These changes can be planned and built into the design of operations, whether it be the use of conservation tillage in agriculture, land reclamation practices for surface mining, or liners and other containment techniques for landfills. These initial costs may be recovered by savings in treating contaminated drinking water or preserving the fertility of soil for crop production.

Agriculture. Agricultural nonpoint source pollution problems may result from land tillage practices, excessive irrigation of highly alkaline soils that dissolve salts, and overapplication of fertilizers and pesticides that leach into groundwater. Sediment deposits from soil erosion may alter not only the hydrology of a stream but by reducing streamflow affect also the oxygen content and temperature of the water. The highest rates of waterborne soil erosion on cropland occur in Iowa, Illinois, Missouri, Texas, Kansas, and Nebraska. In addition, wind erosion is a major cause of sedimentation in Texas, Kansas, and Colorado.

Urban Runoff. Urban runoff is becoming a more serious problem as construction activities increase. Land paved over with concrete funnels heavy metals, oil, and building debris into streams. Over one-half of the nation's river basins are affected by urban runoff sources, the most heavily impacted region being the Northeast.

Mining Operations. Although affecting no more than two percent of the land area in any state, mining can cause significant nonpoint source pollution of both surface and ground water. Principal causes of pollution are sedimentation and acid drainage, and occur principally in the Appalachian region (e.g., Pennsylvania).

Forestry Practices. Although not a significant national problem (it accounts for less than four percent of the man-made sediment load), sedimentation of streams from timber-harvesting and road-clearing operations is a major pollution problem in the primary timber-harvesting states (California, Oregon, Washington, Idaho, Montana, North Carolina, South Carolina, Georgia, Virginia, and Maine). Because forests serve as valuable watersheds, improperly designed silvicultural practices can adversely affect drinking water supply as well as commercial and sport fisheries (e.g., salmon) by silting streams and raising water temperature.

Drinking Water Quality

Public water supply systems are regulated by the U.S. Environmental Protection Agency under the federal Safe Drinking Water Act of 1974, P.L. 93-523. The act requires EPA to set primary and secondary drinking water standards to protect water quality. The secondary standards, which are not federally enforceable, relate to taste, odor, and other quality characteristics that do not directly affect public health. Secondary standards were issued by EPA in 1979. The final primary, health-based standards have not yet been issued, although interim standards went into effect for community drinking water systems (those serving year-round residents) in 1977, and in 1979 for noncommunity systems (those serving transient populations).

The federal act authorizes states to assume enforcement authority for drinking water programs provided a state:

- Has adopted drinking water standards at least as stringent as the EPA's interim or final national primary standards;
- Is implementing adequate enforcement procedures, including compliance monitoring and inspections required by EPA;
- Meets EPA record-keeping and reporting requirements;
- Permits variances or exemptions that are no less stringent than allowed under the act; and
- Can implement a plan for providing safe drinking water in emergency situations.

State drinking water program approval can be revoked by EPA if the state allows a public water system without an exemption or variance to operate in violation of any national primary drinking water standard. EPA runs the drinking water quality program in states where primacy has been declined or not granted.

As noted in the surface water quality section, bacteria is the primary pollutant in surface water. Over 90 percent of all community water systems met EPA's standard for microbiological quality (e.g., fecal coliform bacteria) in 1981. The majority of waterborne disease outbreaks occur in water systems serving less than 10,000 people because of inadequate treatment methods, operator training, and personnel and financial resources.

Nearly 2,000 water supply systems violated EPA's drinking water standard for various inorganic chemicals in 1978-80. The largest number of violations (1,130) were for excessive levels of fluoride, followed by nitrate and/or selenium (590), and other inorganics such as arsenic, lead, barium, chromium, mercury, cadmium, and silver (260). The largest number of noncomplying systems were in Texas (432), California (266), South Carolina and Virginia (122 each), and Arizona (113).

EPA has not issued drinking water standards for many organic chemicals. Prior to 1970, only about 100 different organic compounds had been identified in water. With advances in analytical methods, several hundred additional compounds have been found. The majority of organic chemicals are of natural origin and are generally not harmful to human health. Synthetic organic chemicals such as trihalomethanes and polychlorinated biphenyls (PCBs), may be carcinogenic, however. These contaminants may be caused by industrial and municipal effluent discharges, solid and hazardous waste disposal, residential chemical use, or urban and agricultural runoff. EPA has issued standards for chloroform and other trihalomethanes, and has proposed regulation of 14 additional synthetic organic chemicals in surface and ground water drinking supplies.

Acid Deposition

Acid deposition -- "acid rain" -- is generally defined as the conversion of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) to sulfates and nitrates during transmission through the air and eventual removal from the atmosphere in the form of precipitation. It is caused primarily by sulfur and nitrogen oxide emissions from fuel combustion by utility and industrial power plants, motor vehicles, and other industrial processes.

Sulfate is the dominant component of acid precipitation in the eastern United States while nitrates predominate in the Rocky Mountains, Sierra Nevada Mountains, and southern California. Nitrate in eastern precipitation has roughly tripled since 1955, however, with sulfate doubling during this period. The ratio of sulfate to nitrate in the eastern U.S. is approximately 2:1.

The acidity of precipitation is represented on a pH scale of 0 to 14 with more acidic conditions indicated by values lower than 7 and more alkaline conditions indicated by values above 7. Since the pH scale is logarithmic, each full unit change in pH represents a ten-fold change in acidity; a pH of 3 is ten times as acidic as a pH of 4, and 100 times more acidic than a pH of 5. If rain were in equilibrium with atmospheric carbon dioxide and not subject to any other influence, it would have a mildly acidic pH of about 5.6. In the central and western United States, however, "normal" precipitation pH is usually higher than 5.6. In the eastern United States, it can be lower than 5.6, in part because soils are slightly acidic and cannot provide a neutralizing capacity.

The most common assumption made in relating air pollutant emissions to acid precipitation, especially for SO_2 emissions, is that long-range pollutant transport from several midwestern states' SO_2 sources is responsible for most of the acid deposition in the eastern and northeastern United States and southeastern Canada. This assumption may be justified given the prevailing wind and weather patterns in summer (when SO_2 conversion to sulfate is usually at its maximum), the increase in total SO_2 emissions since 1940 (especially in the electric power sector), the heavy concentration of SO_2 emissions from the major midwestern source states and the construction of many tall exhaust stacks there, and the 2:1 ratio of sulfate to nitrate in eastern precipitation. A recent study at the University of Rhode Island that used two tracer elements to identify the origin of atmospheric particles appears to indicate, however, that acid precipitation in the Northeast stems from a mix of sources in the entire eastern United States -- not just from midwestern sources -- and that specific eastern locations may suffer from predominantly eastern-generated pollutants. Although northeastern locations close to midwestern emission sources may be able to trace acid precipitation to the Midwest, geographic areas further to the north and east may have more complex source identities.

The most frequently reported effects of increased acidity in freshwater lakes and streams are those on fish. Most fish species disappear from lakes when the pH is below 5, with the inhibition of reproduction being the probable cause. An Indiana Institute of Ecology report estimates that nearly 3,000 lakes and 25,000 streams east of the Mississippi River have been "acid altered" as a result of acid precipitation. Lakes and streams in New England, New York, Pennsylvania, the Appalachian Plateau, and Blue Ridge/Smoky Mountains appear to be most sensitive to acid precipitation damage.

PART THREE

WATER RESOURCES POLICY ALTERNATIVES

INTEGRATED PLANNING AND MANAGEMENT

If it is accepted that water resources decisions should be made within the context of how they affect related resource issues, then integrating water planning with other natural resources program planning becomes a logical goal. Additionally, if policies adopted pursuant to planning input are to be implemented effectively, there should be a direct link between the planning process and management capacity. The institutional framework may not be as important as the process by which the linkage is accomplished; planning may be done by different entities and implementation by others. There needs to be some process, however, whereby all the parties involved become aware of the objectives and potential impacts of policy decisions.

Jurisdictional Relationships

Reorganization of several government agencies into a single agency responsible for both planning and management -- while perhaps desirable where authority is severely fractured -- may not be necessary or effective if interagency friction is merely internalized. Where existing management authorities are strong, successful integration may be through informal coordination of activities. Under Florida's Water Resources Management Act, for example, regional water management districts can integrate their water allocation decisions with local government land use plans by considering the impacts on sensitive lands (e.g., aquifer recharge zones, coastal areas) of water-dependent development activities before granting a consumptive water use permit. The South Florida Water Management District has furthered this approach by reviewing the drainage and water supply elements of local land use plans under the state's Local Government Comprehensive Planning Act.

Florida's Local Government Comprehensive Planning Act offers another opportunity for integration of resource planning, this time at the local level. Under its provisions, comprehensive development plans must be prepared subject to state approval. A key element of the plans must be "consistency and coordination"; i.e., all elements of a plan must be consistent with each other, and permitted activities must be coordinated in such a manner as to achieve consistency. Local governments can guide water use and protection of water quality through zoning actions designed to comply with planning decisions on the most suitable activities for designated areas in their plans.

Under Oregon's Land Use Act of 1973, cities and counties are required to prepare comprehensive land use plans in compliance with state guidelines and approval by the state Land Conservation and Development Commission (LCDC). Water resources planning and management is a major consideration in conforming to the state guidelines. For example, areas may only be designated for urban and residential use where sewage disposal alternatives have been clearly identified. In addition, LCDC guidelines call for intergovernmental coordination on a river basin basis to assure that any local plans or programs that would increase waste discharges conform to state water quality and land use plans and programs.

Vermont's Land Use and Development Control Law of 1970 exhibits a similar state/regional/local cooperative framework. A permit is required from one of nine district environmental commissions for construction activities involving more than one acre of land or ten units of housing or subdivision. Regional district permitting decisions may be appealed to the state Environmental Board. The criteria for permit approval include compliance with water quality regulations, consideration of water availability and water conservation measures, and containment of soil erosion from land disturbing activities.

An essential element of integrated resouce planning and management is a clear legislative mandate regarding policy goals and implementation. The legislature can accomplish this goal by writing effective policy consideration requirements into law (e.g., specifying agricultural land preservation, energy conservation, and water conservation criteria to be used by local governments in subdivision planning reviews and other land use decision making, or establishing a future reservation process for water supplies that accounts for competing uses). In other cases, the legislature may need to specify the agenda or alter institutional structures that will allow future environment and natural resource policy decisions to be more thoughtfully made. These actions may include: appointing legislative study commissions to make policy recommendations for immediate consideration and to evaluate long-range objectives and needs; promoting basic and applied research and development activities (both scientific and policy-oriented); and requiring state executive planning and program coordination where necessary.

Use of Interstate Compacts

Because river basins do not adhere to political boundaries, management on a watershed basis will require some degree of interstate cooperation. Interstate compacts offer an institutional framework to achieve this goal. Compacts usually take one of two forms: (1) federal-interstate compacts that attempt to comprehensively plan and manage the water resources of a basin through a single regional governmental entity; and (2) water allocation compacts that divide the water of a basin among member states for management as each state sees fit. An example of the former is the Delaware River Basin Compact; the latter is illustrated by the Colorado River Compact and Upper Colorado River Basin Compact.

The role of the state legislature in establishing effective compacts is critical, for not only will legislative ratification of compacts be required, but legislative involvement in negotiating compacts will also be essential if the necessary input to avoid future operational problems is to be obtained. Continued funding will also require legislative consent, and in the case of the Delaware River Basin Compact, funding commitment is essential to the effective operation of a regional management agency.

Delaware River Basin Compact. The Delaware River Basin Compact is the premier example of a federal-interstate compact designed to comprehensively plan and manage the water resources of a particular basin. The compact itself does not allocate specific quantities of water to each of the basin states, but it establishes a commission to allocate water under certain conditions. The commission is responsible for multipurpose planning, management, and development of the region's water resources, including water supply, water quality, and flood control considerations. It was formed in 1961 among the states of Delaware, New Jersey, New York, and Pennsylvania, and the federal government. The basin's drainage area is approximately 13,000 square miles, and it serves as a primary source of water supply to over 20 million people (including its tributaries and connecting aquifers).

The Delaware River Basin Commission is responsible for formulating a comprehensive plan for the development and use of the basin's water resources. Proposed water projects that would have a substantial effect on the water resources of the basin require the commission's approval. The commission may allocate water among the member states on an equitable basis (an issue of critical importance during water shortages, e.g., the 1980-81 drought), and regulate surface and ground water withdrawals; surface and ground water withdrawals in excess of 100,000 gallons per day (gpd) throughout the basin require the commission's approval, and groundwater withdrawals in excess of 10,000 gpd in a special groundwater protection area in southeastern Pennsylvania also require commission consent.

Colorado River Compacts. The Colorado River Compact is the primary example of a water allocation compact in the United States. It apportions the water of a major interstate stream into two basins encompassing seven states. Unlike the federal-interstate compact in the Delaware River Basin, the Colorado River Compact does not attempt to comprehensively manage the water of the Colorado River within the basin; water allocated to each state is subject to state decisions on individual appropriations.

The compact was adopted in 1922 by the states of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. It apportions 7.5 million acre feet (maf) of water per year to each basin. The apportionment of water to each basin rather than specific amounts to each state has led to conflict among states for the use of water, principally between Arizona and California in the lower basin. It was not until 1963 in Arizona v. California that the U.S. Supreme Court finally divided the water of the lower basin among Arizona, California, and Nevada. The court decision confirmed the allocation formula contained in the federal Boulder Canyon Project Act of 1928, awarding 4.4 maf/year to California, 2.8 maf/year to Arizona, and 0.3 maf/year to Nevada.

Specific allocations of water to the upper basin states were made in 1948 with the adoption of the Upper Colorado River Basin Compact. Like the Colorado River Compact, the upper basin agreement was not intended to comprehensively manage the water resources of the basin but to have appropriation decisions made by individual states. Of the 7.5 maf of water allocated to the upper basin, Arizona was alloted 50,000 acre feet per year with the balance awarded on the following basis: Colorado - 51.75 percent, New Mexico - 11.25 percent, Utah - 23 percent, and Wyoming - 14 percent.

Problems Affecting Compacts. The primary problem affecting the Delaware River Basin Compact is endemic to the institution established to manage the basin's water resources -- states are reluctant to give up sovereignty over matters that affect them directly to an independent commission. The Delaware River Basin Commission was created largely because of the fears of some basin states that New York City would continue to divert large quantities of water out of the basin. In that instance, a loss of a measure of local control over water allocation was determined to be worth regulation of the overall basin's supply. For New York, however, a similar rationale did not exist for the continued regulatory presence of a multi-state agency in water decisions of questionable basinwide importance. (New York's full financial contribution to the commission is in doubt because the state feels the downstream states are receiving most of the compact's benefits). The question of what comprises an impact of basinwide significance is critical to the credibility of a regional management entity; if the member states determine that a commission is regulating water uses that only affect a single state, its authority -- and future effectiveness -- may be compromised.

The major problem affecting the two water allocation compacts in the Colorado River Basin is the uncertainty over the actual amount of water available for use; this emphasizes the need for sound data in making water decisions. When the Colorado River Compact was adopted in 1922, the average annual virgin flow of the river was estimated at 17 maf. During the period since adoption, however, the average annual virgin flow has declined to approximately 13.7 maf (or less than the amount allocated to both basins). Because the upper basin is required to let 7.5 maf flow into the lower basin each year (or 75 maf in any 10-year period), any future shortfall could impede water development in the upper basin. Complicating the supply issue is the impact of water quality on water quantity; full use of the river has increased salinity concentrations in the lower basin as less water is left to assimilate dissolved minerals. This quality/quantity relationship suggests the need for an integrated planning and management approach to any major basin's water resources if the supply of high quality water is to be maximized.

WATER QUANTITY POLICY ALTERNATIVES

This section discusses several specific water quantity related policy options, including different approaches for surface and ground water allocation, conjunctive management of both sources, interbasin transfers, water conservation and reuse, and financing water projects. The policy options relate back to many of the problems and issues addressed earlier. It must be emphasized that discussion of a specific alternative in no way connotes approval or disapproval of such an approach.

Surface Water Allocation

Managing water use generally requires some degree of control over allocation, especially if the resource is scarce and the goal is to integrate water and related resource decision making. Regulation may take the form of a permit system, either on a statewide or watershed basis. At the state level, applicants for large amounts of water (generally for all but domestic uses) would seek a permit from a state agency. The permit would normally be granted if there is sufficient water available, the proposed use serves a beneficial purpose, waste does not occur, the means of diversion is adequate, and existing water rights are not impaired. Using this approach, those in charge can perceive and prevent potential water shortages caused by overuse before they occur. The permit system, however, does not by itself provide effective resolution of conflicts during periods of short supply. Statewide permit systems based upon the doctrine of prior appropriation -- which grants rights to water based upon the date of first use -- are prevalent in the western states where there was a historic need to divert scarce water from its source for mining and irrigation. Permit requirements have also been adopted in some eastern states that rely on the common law riparian rule, which accords water rights based upon ownership of land appurtenant to the source of water. In those states, the criteria for permit approval may be based on a priority of use formula, rather than on priority in time of use, whereby certain types of uses are granted preference over others; e.g., domestic over agriculture, agriculture over power generation, power generation over manufacturing.

More intensive management of a particular water basin is possible using a critical areas approach. In this instance, a state agency is authorized to declare the existence of critical areas where it determines that water levels are or will be declining at excessive rates unless management is undertaken. Once such a designation is made, the agency -- or local or regional water management district -- may regulate use through several options: apportioning of supply among existing users on an equal basis, according to the date of first use, or within a priority of use framework; placing limitations on new or expanded uses; or closing the area to new uses. This approach may be most appropriate in those states with isolated supply problems, but it generally assumes the existence of a problem and will be ineffective in preventing shortages unless there is sufficient information in advance on current water use and available supply.

The following case studies illustrate alternative approaches to the allocation of water resources. General riparian and appropriation systems are not discussed because of earlier reference to them in this section. The states selected attempt to relate water use decisions to other resource concerns, primarily growth and environmental protection issues.

Florida. A unique two-tiered approach is employed in Florida for the allocation of water resources. The Water Resources Management Act of 1972 (FS, Chapter 373) authorizes five regional water management districts, organized along hydrologically sound lines taking into consideration the interrelationship of surface and ground water, to issue permits for water use. The district permit systems must be approved by the state Department of Environmental Regulation before being implemented. The basis for permit approval is reasonable-beneficial use, which requires that the quantity of water be efficient for application of the use and that it be used for a purpose that is both reasonable and consistent with the public interest in relation to other uses.

The districts are also required to formulate water shortage plans with specific classifications of use that will be curtailed during droughts or other water emergencies to provide for efficiency and certainty in crisis management decisions. No final shortage plans have been completed to date although the South Florida Water Management District has prepared a draft plan that will undoubtedly be the basis for other district plans to follow. The South Florida district has also been a leader in integrating other resource considerations into water allocation decisions through its review of the water quantity, quality, and land use impacts of proposed construction activities within its permitting jurisdiction.

Montana. The doctrine of prior appropriation is utilized in Montana for allocating surface water, with a permit required from the state Board of Natural Resources. In addition to this system for administering existing water uses, the state has an innovative approach for guaranteeing the allocation of water for future uses. Under its reservation process, the state or any political subdivision may petition the board to set aside specific amounts of water in a river basin for general categories of use (e.g., agriculture, industry, instream flows). The statute (MCA, 85-2-316) authorizes the board, after holding public hearings, to establish priorities for future uses and reserve specific amounts of water for each use. The priority date of each reserved water right is the date of the reservation, not the date the right is actually exercised. This process has the indirect effect of allowing the state to determine where certain types of growth dependent upon adequate water supply will occur. It illustrates the interrelated nature of water and land use and how legislative policy can integrate them into a single decision making framework.

Connecticut. Connecticut is the most recent example of a riparian water rights doctrine state that has gone to a permit system for major water diversions or withdrawals. The 1982 statute (P.A. 82-402) requires new surface or ground water diversions or withdrawals in excess of 50,000 gallons per day to obtain a permit from the Department of Environmental Protection. In addition to information regarding the location and quantity of water to be diverted or withdrawn, the application must describe the effect of the proposed use on the area's water supply, water quality, and related resources (e.g., wetlands, agriculture), and contain a conservation plan for implementation. Applicants for interbasin transfers must prepare an environmental impact report that (1) analyzes the effect of the diversion on the present and future water needs of the basin of origin; (2) contains a plan for meeting the water needs of the basin of origin; and (3) addresses alternative solutions to the proposed diversion with a cost analysis of the proposed diversion and alternatives.

Groundwater Allocation

Groundwater may be allocated using approaches similar to those for surface water: (1) little or no regulation of use under common law rules that grant the overlying landowner a right to the groundwater beneath his land; (2) permit systems requiring a permit from a state agency for withdrawals for all but domestic purposes; and (3) permit systems requiring a permit from a state agency for withdrawals in designated areas only where intensive management is required to prevent depletion and related water quality and land use problems. In the latter case, local groundwater management districts may also be established to manage groundwater use in conjunction with a state agency through the adoption of regulations apportioning the existing supply among all users, closing the aquifer to new uses, rotating the timing of withdrawals, establishing well-depth or well-spacing requirements, and setting maximum pumping rates.

The implementation of groundwater allocation strategies has a direct impact on land resource policies and clearly illustrates the relationship of water quantity to water quality. The following case studies bear this out.

Arizona. The uncontrolled use of groundwater in Arizona has led to serious problems of aquifer overdraft, land subsidence, and saltwater intrusion. The annual rate of depletion is 2.5 million acre feet; in Maricopa County (Phoenix) the rate exceeds natural recharge by over 30 times. In an attempt to address these and other water management issues, a groundwater management act (ARS 45-401 et seq.) was adopted in 1980. The act established four active management areas (Phoenix, Tucson, Prescott, and Pinal County) where restrictions on groundwater use will be imposed. Within each area, existing groundwater users are entitled to a grandfathered right in the amount of their historical use. The statute requires the implementation of conservation plans, water measuring devices, and reports on water use, and prohibits the development of new acreage for irrigation without a grandfathered right. Although municipal water suppliers may increase their water use to meet expanding needs, new or expanded industrial uses require a permit from the Department of Water Resources (a certificate of assured water supply must be obtained from the department before a new subdivision can be developed). A groundwater pumping fee will also be levied to provide funds for administration and enforcement of the law, and eventually for augmentation of water supply and purchase and retirement of groundwater rights.

Arizona's Groundwater Management Act is a good example of how water and related resource issues can be integrated in the policymaking process. The act is designed to manage a finite resource. Limitations are placed on the development of new land because of the water-dependent nature of land use activities in this arid state. Because agriculture controls most of the water rights in the state -- it accounts for nearly 90 percent of water consumption -- it will impact the pattern of growth. As development pressures increase, the pressures on agricultural water rights holders to sell their water for other uses may have serious ramifications for the future of agriculture in the state unless effective conservation programs are adopted or alternative sources of water are developed.

Nebraska. Nebraska's Groundwater Management Act (RSN, 46-656 et seq.) employs a two-tiered approach that authorizes the state Department of Water Resources to designate groundwater control areas where it determines there is insufficient water to meet existing or potential uses or that the continued unregulated use of groundwater would cause pollution of the aquifer, and to issue permits for new groundwater withdrawals in designated areas. Once a control area is designated, local natural resources districts (the state has 24 districts) must adopt regulations governing groundwater use. The regulations may place restrictions on the quantity of groundwater withdrawn, impose well-spacing requirements, rotate withdrawals among all users, or close the area to new uses. The water quality criteria used in designating protected aquifers gives the Department of Water Resources and local natural resources districts the authority to regulate irrigation when it results in the percolation of dissolved fertilizers and pesticides into groundwater basins.

Oklahoma. The state water Resources Board regulates groundwater withdrawals through a permit system (OSA, 82-1020.1 et seq.). In addition to its regulatory authority, the board's planning functions are equally significant. The board is required to conduct a hydrologic survey of all groundwater basins in the state (to be updated every 10 years) and to determine the maximum annual yield and equal proportionate share per acre of overlying land in each basin. It may also establish well-spacing requirements to prevent groundwater depletion, and order the use of well-metering devices if requested by a majority of landowners in a groundwater basin.

Unlike its surface water allocation system, which is based upon the doctrine of prior appropriation, the state's groundwater allocation system contains a modified element of common law. To qualify for a permit, an applicant must own or lease the land overlying the proposed point of withdrawal. The quantity of water to be allocated is based upon two criteria: (1) the correlation of the volume of water in the aquifer to the number of acres of overlying land, with the applicant receiving an equal proportionate share; and (2) the availability of water sufficient to maintain the life of the aquifer for at least 20 years.

Conjunctive Management

Conjunctive management is the coordination of surface and ground water use to maximize total water availability. In those states with statutory water allocation systems, an administering officer may be required to determine the effect of a groundwater application on surface water levels before granting a permit. If the proposed groundwater use would lower the streamflow by diminishing the volume of discharge from the aquifer into the surface body, the application may be denied because of its impact on existing surface water rights.

Conjunctive management may also involve the storage of excess surface water in aquifers to offset future shortages in surface supply or alleviate groundwater depletion problems. Aquifers can be artificially recharged by applying water to permeable overlying land or by injecting it into wells. The savings in construction costs for surface reservoirs and energy usage from not having to pump groundwater from declining levels can be substantial.

There are several environmental advantages to storing surface water in underground basins. Disruptions to land activities and the adverse impacts on streamflows associated with dam construction and operation are avoided, as is the loss of water to evaporation from impoundment in large surface reservoirs. Water in aquifers can be of a higher quality than surface water because of the natural filtration characteristics of the soil and less exposure to pollution. Perhaps most important, maintaining groundwater levels through an artificial recharge policy can avoid aquifer depletion and the negative impacts of saltwater intrusion and land subsidence.

Although carrying several environmental and economic advantages, the use of underground storage may raise legal and other problems. A potential hindrance to the employment of conjunctive management is the legal question of who has a right to the use of water in underground storage. If a private landowner can claim a right to water imported and stored beneath his land by a public agency wishing to withdraw it later, there will be no incentive for conjunctive management. Because underground storage requires the importation of surface water, interbasin transfers may be required. In such instances, the need for diversion facilities and the legal flexibility to divert water away from its basin of origin may preclude the use of available underground storage.

Conjunctive management has been most actively implemented in California at both the state and local levels. The role of the state Department of Water Resources has been to identify aquifers with sufficient storage and recharge capacity, and to develop its own wells or negotiate agreements with local water districts to pump and sell water. Orange County in southern California has a successful program that not only makes use of surface water to enhance groundwater supply but also to repel saltwater intrusion through injection of freshwater into wells along the coast.

Interbasin Transfers

Interbasin transfers are the most direct means of providing large quantities of water for augmentation purposes. They have become an important means of meeting water needs in areas with limited indigenous supplies. Because they are capital intensive, however, cost considerations can affect their implementation. Other potential constraints include legal rights to water being diverted and adverse environmental impacts in the exporting river basin.

Two considerations must be met before an interbasin transfer can be justified on an economic basis: (1) the addition to income in the importing river basin must exceed the loss of income in the exporting basin, plus the cost of the transfer system; and (2) the cost of the transfer system must be less than the cost of the best alternative for supplying the same amount of water. A major problem in determining economic benefits, however, is quantifying social and environmental values such as aesthetics and instream flows that may be adversely affected by large-scale diversions.

The most obvious environmental impact is reduction in streamflow levels. This reduction can adversely affect fish and wildlife habitat as well as the ability of a stream to assimilate and dilute waste discharges and dissolved minerals. Additionally, groundwater levels may decline as water that would normally return to the basin of origin and recharge aquifers is diverted elsewhere.

The water rights system employed in a state may also affect the use of interbasin transfers. In states that adhere to the riparian doctrine, water use is generally restricted to lands bordering the point of diversion (although this restriction has been modified in some states to require a riparian owner to show pecuniary damages as a condition to stopping such transfers). The use of water in those states adhering to the doctrine of prior appropriation is not generally restricted to riparian lands (although basin of origin statutes may require that the reasonable present and future needs of the exporting basin be met before a diversion takes place). The doctrine of equitable apportionment usually governs disputes among states over the diversion of water from an interstate stream.

Interbasin transfers in the Connecticut River Basin and in California illustrate two examples of how large-scale water transfers are used to meet a portion of a state's water needs.

Connecticut River Basin. Water use in metropolitan Boston has been exceeding the safe yield by approximately 15 million gallons per day (mgd) over the last 10 years (315 mgd demand vs. 300 mgd reliable supply). An interbasin transfer from the Connecticut River watershed currently provides the area with approximately two-thirds of its average daily water needs. The Metropolitan District Commission (MDC) is studying the possibility of an additional diversion from the Connecticut River Basin at Northfield Mountain that was authorized by the legislature in 1967 and 1970 (the proposed diversion could increase the service area's safe yield to approximately 375 mgd; preliminary projections by the MDC of future water needs based upon past trends imply a 1990 demand of 359-385 mgd, and 504-625 mgd by the year 2020). If a diversion proposal is approved, opposition from Connecticut -- which lost a U.S. Supreme Court decision against the original diversion in 1931 -- can be expected on the basis of potential adverse environmental and economic impacts in the lower basin.

California. The California State Water Project (SWP) is the largest example of an intrastate interbasin transfer in the country. The SWP consists of reservoirs on the Feather River system in northern California which channel water into the Sacramento River. The Sacramento flows into the Delta wetlands east of San Francisco Bay, where water is pumped and sent south via aqueducts for use in service areas, primarily for irrigation in the San Joaquin Valley and municipal use in southern California. The project began in 1960 with passage of the State Water Resources Development Bond Act by a narrow 51-percent approval of the electorate. The act authorized the sale of $1.75 billion in general obligation bonds for construction of necessary facilities.

The SWP delivered nearly two million acre feet (maf) of water to contractors in 1975; 61 percent went to the San Joaquin Valley and 30 percent to southern California. Of the maximum annual quantity of water contracted for use (4.2 maf), southern California has the largest share -- 2.5 maf (59 percent) -- with the San Joaquin Valley entitled to 1.4 maf (32 percent). The first year of maximum entitlement deliveries for most water contractors is expected to be 1990. The 1982 defeat of the proposed Peripheral Canal and the consideration of alternative water transfer systems and groundwater management and conservation programs may affect the final water use schedule.

Water Conservation

Water conservation has been hindered by two factors: (1) water has traditionally been an inexpensive commodity and most urban areas have used declining block rates for payment of water use which discourages conservation (federally subsidized irrigation water has had the same effect); and (2) there is a widespread public perception that conservation requires doing without some necessity and precludes economic growth. Water conservation can offer several economic and environmental benefits, however. A reduction in peak use, for example, may result in lower water costs and less need for water supply and treatment capacity (which are costly, capital-intensive ventures). Municipal sewage treatment plants may then benefit from a reduction in wastewater flows, thereby extending their usefulness, reducing energy requirements, and preserving water quality by cutting waste discharges to receiving waters. Agricultural water conservation may extend the life of cropland by reducing salinity in soils from dissolved minerals caused by excessive irrigation.

As the largest consumer of water on a national basis (80 percent of national water consumption in 1975), measures designed to conserve agricultural water use -- principally irrigation -- will have the greatest potential impact on water supply (although the benefits may be confined to specific geographic areas where irrigation is predominant). Agricultural water conservation techniques include:

- Lining conveyance systems to reduce water seepage loss;
- Increasing water use measurement capability to provide more accurate information on actual water use;
- Scheduling water deliveries to more clearly reflect crop needs, weather, and soil moisture;
- Controlling unwanted vegetation that consumes irrigation water;
- Contouring field surfaces to achieve uniform application and holding of applied water;
- Installing tailwater -- runoff -- recovery systems (where this would not affect return flows for which downstream users hold water rights); and
- Switching to crops requiring less water.

Industrial water use also offers several opportunities for conservation. The implementation of state and federal water pollution control requirements may serve as an additional incentive to avoid unnecessary water use that may result in increased waste discharges. Industrial water conservation techniques include:

- Replacement of once-through steam electric cooling systems for energy generation with alternative systems that recycle water (although the alternatives can substantially reduce water withdrawals, they are highly consumptive);

- Recovery and reuse of steam and other process condensates;
- Use of clarification or other treatment techniques to upgrade process water for reuse; and
- Use of saline water or municipal wastewater where appropriate.

More advanced technologies for industrial water conservation, some of which may also improve energy efficiency and reduce wastewater effluents, include vapor compression evaporation, waste heat evaporation, reverse osmosis and ultrafiltration, electrodialysis, steam stripping, combination wet/dry cooling towers, air-fin cooling, and cooling tower sidestream softening.

Two of the most controversial water conservation measures aimed at reducing domestic consumption are metering and changes in pricing policies to reflect actual water use. Because metering alone does not significantly affect water use, its main purpose is to accurately account for water use for water supply planning and leak detection (as well as to insure proper utility revenue collection). Changes in water pricing structures that charge more for each unit of increased water use can affect both indoor and outdoor water use (although after the installation of conservation devices in response to pricing, indoor uses become relatively price-inelastic because they involve necessary functions). Revenues obtained from flattening out declining block rate charges and imposing summer surcharges for outdoor uses (e.g., lawn watering) may be used to finance water supply system expansion and improvement or to reduce the need for new, expensive water supply or treatment capacity. To minimize the economic impact on low-income and elderly residents, any increasing rate schedule could be designed initially with larger water blocks and be changed gradually to smaller blocks and increasing rates, along with increased prices within each block.

Water Reuse

Municipal and industrial wastewater can provide a large volume of water for reuse in much of the United States. It is an especially attractive alternative to freshwater supplies where freshwater is limited; new supplies must be developed at increasing expense; or large water users are satisfied with lower water quality at less cost. When properly treated, wastewater may be used for groundwater recharge, agricultural irrigation, industrial processes such as steam electric cooling, and urban and residential purposes (landscaping and lawn watering, toilet flushing).

Although advantageous for many types of uses, wastewater reuse can also carry environmental and health risks. Impediments to its use include: potential health risks and product liability from insufficiently treated water; cost of treating wastewater to meet reuse application needs; possible reduction of instream flows and harm to water rights holders from discharges put to other uses; and public acceptance.

The primary use of wastewater is for agricultural and landscape irrigation. Of 536 reuse projects in operation in the United States in 1979, 470 were for irrigation (primarily in California, Texas, Arizona, and New Mexico). From 1971 to 1979, the number of reuse projects in the United States increased by 25 percent (430 to 536). The largest percentage increases in projects were industrial (15 to 29) and recreational/environmental (5 to 26).

There are three major factors affecting water reuse: (1) sources and markets; (2) health and environmental impacts; and (3) economics and financing. Municipal and industrial treated effluents are the most likely sources of water for reuse. The volume and cost of a potential reuser's water consumption -- and fluctuations in demand -- must be considered, along with the quality of water needed, before the benefits of using treated wastewater will be realized. The cost savings of water reuse can be substantial when compared to the costs of developing new freshwater sources for irrigation, industrial cooling, and groundwater recharge.

When considering wastewater for reuse, municipal and industrial effluents must be analyzed for the presence of heavy metals or other inorganic chemicals, synthetic organic chemicals, and traditional water quality parameters. Several states (e.g., California, Arizona, Texas, Florida) have adopted regulations or guidelines for reused water for irrigation, recreational, environmental, groundwater recharge, and other purposes.

and increased production in the low-sulfur coal areas of central Appalachia.

An additional policy measure is the imposition of an emission charge or tax on the generation of SO_2 and NO_x. Emission charges have been successful in Japan and in reducing industrial wastewater discharges in the United States. Such a charge could be used to stimulate the development and application of more effective pollution control technology.

PART FOUR
PREVIEW OF LAND RESOURCES REPORT

The land resources report in the second year of the NCSL Environment and Natural Resources Project study is a natural outgrowth of the water resources report. Land policies affect both water quantity and water quality. A single example should suffice to illustrate this connection. The conversion of prime agricultural lands to urban and energy uses may force the development of more marginal lands to meet growing domestic and world food needs. To make marginal lands productive, intensive irrigation and chemical treatment may be required. Large water withdrawals can lead to groundwater overdraft and saltwater intrusion; extensive use of fertilizers and pesticides may leach nitrates into aquifers and surface water bodies. These activities can lessen the supply of water available for other uses through resource depletion and degradation of quality. As entire rural economies build up around such unmanaged practices, the question of maintaining the fiscal well-being of people becomes an issue of equal or greater importance than the physical resource problem.

Because of these interrelationships, land resource issues will be examined from the dual perspective of how they impact resource availability and environmental quality. Specific land issues studied will include the following:

> Sensitive lands -- prime farmland, forests, flood plains, coastal zone, wetlands.
>
> Energy development -- facility siting, land reclamation.
>
> Agriculture -- soil erosion, increased productivity, irrigation efficiency.
>
> Public land management -- multiple use, energy development, wilderness designation.
>
> Growth management -- water policies, energy demand, infrastructure financing.

Resource issues and problems will be identified in each area, followed by discussions of state, local, and where appropriate, federal, policies to achieve more effective resource planning and management within the goal of environmental protection. Case studies will be used extensively to illustrate critical problems and alternative approaches to resolving them. The role of the legislature in policy initiation and implementation will be emphasized.

Economic considerations involved in determining the viability of reuse projects include: additional water treatment costs to make wastewater usable; storage, transportation and distribution costs compared to those of alternative water sources; and the cost of monitoring reclaimed water quality. Reuse projects can be financed entirely with local revenues (e.g., the sale of general obligation or revenue bonds), or with state and/or federal funding support. A fee may be charged by public entities for the distribution of wastewater that would otherwise be discharged to raise additional revenue or to meet debt-service on reuse facilities. Pricing policies may be set to stimulate water conservation, make water reuse more attractive to potential users, and be financially worthwhile for municipalities and water and sewer districts.

Financing Water Projects

Financing water projects bears a direct relationship to other resource issues, especially land. Water projects -- both for supply and wastewater treatment -- are a key element of municipal, industrial, and agricultural infrastructure. Because of decreased federal funding for water supply and sewage treatment plants and legal and budgetary constraints on local capacity to raise revenue, states will be required to provide additional financial assistance for such projects.

The primary means of acquiring capital for water project development is debt financing. Debt financing is usually accomplished through the issuance of bonds -- general obligation or revenue -- by state or local governments. Because local governments do not always have the highest credit ratings or available debt, they may benefit from state assistance in the bond market. The primary options for providing such assistance include economic development funds, bond banks, and enterprise authorities.

Economic Development Funds. The purpose of economic development funds is to provide loans or grants for project development. They are usually financed through the issuance of state general obligation bonds. Where constitutional or statutory constraints on maximum interest rates exist, revenue bonds are often used as an option. As an alternative to bonds, states may use general fund appropriations. Other funding sources include tax surpluses, sales and use taxes, mineral leasing funds, and oil shale trust funds (in Wyoming, the principal source of the state's economic development fund is a portion of the oil and gas severance tax and the coal severance tax). As an alternative to making grants and loans from the fund, some states use the revenue to purchase municipal bonds for specific projects. Another option is to pay for a portion of the project's construction costs, take title to the project, and then sell it back to the sponsor over a long period of time.

Bond Banks. Bond banks are used to purchase bond issues from local governments having difficulty marketing their bonds. Through state bond banks, the cost to local governments of issuing debt is lowered, and at the same time, their expertise in dealing with debt is raised. For bond banks to be successful, however, there must be enough small bond issues to justify a bond bank program; there must be enough local governments experiencing difficulty marketing their bonds; and there must be enough of a differential between the expected bond rating of the bond bank and the majority of local governments issuing debt to make the bank's bonds more marketable.

Enterprise Authorities. Enterprise authorities may be created at the state level to issue state bonds, build projects and lease them to local governments, make loans and grants to local governments, and buy local government bonds. They may be established at the local level by authorizing a number of local governments to form a special district with the power to issue debt.

Two other mechanisms for assisting local governments in debt financing are user fees and leasing arrangements. User fees shift the cost of financing projects to the direct beneficiaries and include power sales revenue, water sales revenue, and recreational facility charges. User fees usually provide only partial funding for a project but they can aid in access to capital markets and relate water prices directly to consumption.

Leasing arrangements can offer advantages over debt financing. Because of the tax benefits to a private lessor who arranges for financing and builds the project -- such as a depreciation allowance and tax-exempt income -- the lessor can lease the property to a city at a relatively low cost. This arrangement also avoids any debt obligation on the government's part.

WATER QUALITY POLICY ALTERNATIVES

This section discusses several specific water quality related policy options, including different approaches for groundwater protection, preservation of instream flows, nonpoint source pollution control, maintenance of drinking water quality, and acid deposition. The policy options relate back to many of the problems and issues addressed earlier. It must be emphasized that discussion of a specific alternative in no way connotes approval or disapproval of such an approach.

Groundwater Protection

There are two basic policy approaches at the state level to protecting the quality of groundwater. One approach regulates specific sources of discharge on an individual basis. This usually involves the adoption of separate statutes for different types of activities that may cause pollution of an aquifer; e.g., hazardous waste landfills, underground injection wells, surface mining operations. A permit may be required as a prerequisite for each activity.

An alternative means of protecting groundwater quality involves some form of aquifer classification and/or standard setting. This approach usually begins by establishing either a nondegradation (i.e., limited pollution up to a specified level) policy for aquifers based upon natural background characteristics and designated uses of an aquifer. It may then provide for identification and mapping of aquifers; classification of aquifers according to present and future uses (e.g., drinking water, industrial, irrigation); adoption of groundwater quality standards based upon classification of use; and establishment of a permitting system for waste discharges to guarantee compliance with the groundwater quality standards. Such an approach may apply to all groundwater statewide or only to critical aquifers. New York, Connecticut, and New Mexico are examples of states that have adopted aquifer classification and standard-setting programs.

Another state approach to preserving groundwater quality involves protection of critical aquifers. Water quality standards may be adopted and waste discharges regulated on the basis of compliance with the standards. Examples of major aquifers being protected by this approach are the Central Pine Barrens in New Jersey and the Edwards Aquifer in Texas.

Local governments can also play a critical role in protecting groundwater quality, especially since politically sensitive land use decisions traditionally rest at the local level. There are several options for protecting groundwater at the local level. These include: land use zoning, acquisition of land used for recharge zones, on-lot disposal system requirements, regulation of solid and hazardous waste disposal, mandatory clustering of building units, and transfer of development rights. Combinations of these programs are being used on Long Island, New York, Cape Cod, Massachusetts, and Dade County (Miami), Florida, among other places.

Instream Flows

Unlike uses of water for domestic, irrigation, and industrial purposes -- which are withdrawn from a water body and often consumed in the process -- water for instream flow uses remains within the streambed. Instream uses serve valuable environmental functions, including preservation of fish and wildlife habitat, maintenance of water quality through assimilation of waste discharges, and enhancement of aesthetic values and recreational opportunities. Minimum streamflows may also be required for navigation and hydroelectric power generation.

Because it is difficult to place an economic value on instream uses and to accurately quantify minimum flows necessary for various instream purposes, they have been assigned a lower priority compared to other water rights in many instances. The problem of measurement raises an important distinction between volumes of water necessary for different instream values. Requiring water sufficient to meet the most stringent instream needs in all segments of a river may not be necessary to protect the primary environmental purposes of a specific reach; a balance may be struck whereby withdrawals can occur without adversely affecting legitimate instream needs.

Preserving water for instream flow purposes is a complex issue in many western states where the doctrine of prior appropriation governs water use. The basic problem is that this water rights doctrine was designed to reduce a common resource -- water -- to individual ownership in order to gain the greatest beneficial use of the water. Because instream values are primarily for the benefit of the public, they have run into conflict with existing private rights to water for other purposes; these private rights are protected through constitutional or statutory provisions. As instream values have become more important in recent years, a majority of western states have enacted statutes defining the preservation of fish, wildlife, and recreation as beneficial uses.

There are several different methods available to a state for preserving instream flows. They include: (1) public appropriative rights to specific amounts of water (which place instream flows on a par with water rights for other purposes); (2) legislative withdrawals of a designated stream from the appropriation process (e.g., California's designation of wild and scenic rivers); (3) administrative reservation of water for various uses, including instream flows (e.g., Montana's future reservation process); and (4) administrative review of permit applications taking into consideration the impacts of the proposed use on instream flows (e.g., California).

Nonpoint Source Pollution Control

Because most nonpoint source pollution problems are related to land-disturbing activities, effective policy alternatives will require changes in land management. Actual land uses may not be changed, but the manner in which they are conducted may be altered, an important political and regulatory distinction.

Nonpoint source pollution control strategies for agriculture can have two major benefits: protection of water quality from soil erosion and sedimentation, and preservation of soil fertility. Land management techniques that can control the level of soil erosion and sedimentation include conservation tillage, terracing, contouring, stripcropping, and construction of flood control and water drainage projects. To implement land management techniques, states have considered several different soil erosion and sediment control approaches. Voluntary programs usually involve technical or financial assistance to farmers as incentives for conservation. Regulatory programs may require the establishment of maximum permissible soil loss limits and an approved soil conservation plan for land-disturbing activities. A state cost-share fund may also be set up to help farmers defray some of the costs of implementing conservation practices.

Iowa's soil conservation program is the most comprehensive effort designed to control agricultural nonpoint source pollution and preserve soil fertility. Its goal is to reduce soil erosion to nondepleting levels by the year 2000. The statute requires local soil conservation districts to establish maximum permissible soil loss limits for each farm within the district. Landowners who exceed the limits must implement land conservation practices, provided public cost-share funds are available to assist in the effort.

Programs designed to reduce urban nonpoint source pollution center on better management of construction activities to reduce runoff into surface waters. Local governments can be given authority to regulate water quality problems associated with construction activities in the same manner as for issuing building permits. Because a land developer is made aware of water quality criteria before he begins construction, the program can be designed into the building process with the costs amortized over time. Maryland and New Jersey are examples of states that have regulatory programs designed to control pollution from urban and commercial land-disturbing activities.

Drinking Water Quality

The major needs of states in strengthening safe drinking water programs involve increases in monitoring and inspecting public water systems, training water treatment plant operators, technical assistance, and financial and other resources for small water systems. Because of cutbacks in federal financial assistance -- which provided between 36 percent and 87 percent of a state's total drinking water program costs in fiscal year 1982 -- state and local governments will be required to raise additional revenue or employ more efficient management practices if drinking water programs are to be maintained at existing levels.

One financial alternative is to institute or increase water supply permits or processing fees. This mechanism makes up 15 percent of Nebraska's water supply agency's budget; in Massachusetts, the figure is less than one percent. Other financial options include increasing water rates, issuing state or local bonds, and state appropriation of general funds.

If increasing revenue cannot be achieved, small water systems may consider entering into agreements with other water suppliers to become part of a regional water system in order to meet federal drinking water standards. The physical interconnection of several small systems may achieve economies of scale and minimize the health risks associated with larger treatment systems. Installing point-of-use (home) water treatment devices also may be a useful option where small communities have difficulty meeting EPA standards.

Complying with primary, health-based standards may be achieved by using differential application of certain standards that are not likely to adversely affect public health. Unlike the federal Clean Air Act and Clean Water Act programs, the effects of drinking water programs are felt locally (not downwind or downstream). Additionally, allowing some differences in local drinking water quality choices is not likely to have an impact on facility siting decisions by business and industry as is the case under the Clean Air and Clean Water acts. Other than where bacterial water quality is poor, or where inorganic or organic chemicals pose a significant health hazard, some flexibility in the application of existing uniform standards may be necessary or desirable if an appropriate degree of compliance is to be obtained.

Technical alternatives can also be employed. While there are several treatment technologies that can be used for inorganics control (e.g., activated alumina and ion-exchange for fluoride removal, ion-exchange and reverse osmosis for nitrate removal), many of these have not been tested on an adequate scale for widespread use; some can be very expensive. Where natural levels of inorganic chemicals are not high -- and synthetic organics are not usually present -- "package" water treatment plants can be successfully used for small systems. These plants use prefabricated and preassembled clarification and filtration units requiring minimum on-site construction, and cost much less to build and operate than conventional treatment plants.

Acid Deposition

Controlling acid deposition will require coordinated federal/state efforts because of the interstate nature of the problems. A state experiencing environmental damage from acid rain will not be able to control the damage acting alone because the source of emissions may be in another jurisdiction. Federal and regional efforts will be required.

The federal Clean Air Act has been ineffective in controlling the interstate transport of pollutants. A major reason is that the Environmental Protection Agency has not issued air quality standards for sulfates and nitrates, the primary components of acid rain. Because of the lack of standards for sulfates and nitrates, the act's provisions prohibiting any stationary source from preventing another state from attaining any national air quality standard or interfering with another state's program to prevent significant air quality deterioration are useless in combatting acid precipitation.

There are basically two approaches open to the states to address interstate transport of pollutants. The first is establishing ambient air quality standards for sulfates and nitrates. For this strategy to be effective, however, states would have to maintain extensive monitoring efforts and the Clean Air Act would probably have to be amended to prohibit any out-of-state interference from a group of pollution sources (rather than from just a single source) with the attainment of any state (not just federal) ambient air quality standard.

Secondly, regional control may be achieved through the designation of interstate areas as air quality control regions or the enactment of regional compacts. Either option would require subststantial consultation and cooperation among states and EPA approval.

States may be able to affect the amount of nitrogen oxides (NO_x) in acid rain by regulating fuel burning by electric utilities and industrial sources and emissions from motor vehicles. The technology exists to reduce emissions from electric utility and industrial sources but the economic costs are high and operational constraints preclude the use of newer techniques on a large-scale basis. Vehicle emissions inspection and maintenance programs may help off-set part of the NO_x problem along with strategies to reduce car use such as improved public transportation and car pools, land use planning, and car use disincentives (e.g., higher fuel taxes and parking fees).

The U.S. Senate Committee on Environment and Public Works recently addressed the sulfur dioxide (SO_2) problem by reporting legislation requiring an 8 million-ton reduction in SO_2 emissions from the total 1980 level in the 31 states east of and bordering the Mississippi River by January 1, 1995. Compliance with the reduction schedule could cost the 31 states between $3.5-5.9 billion, with additional total capital costs to eastern electric utilities of about $13 billion. This would translate into electricity rate increases for some of the states in the region, (mainly Indiana, Kentucky, Missouri, Ohio, Pennsylvania, Tennessee, West Virginia), and reductions in others. The proposed legislation could also lead to regional shifts in coal production and employment, with reductions in coal production in the high-sulfur coal areas in northern Appalachia and the Midwest

PART FIVE

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Chapter 3
Water Policy and Institutions

The development and management of American water resources have been influenced by many social, political, organizational, and economic factors. Unfortunately, many of these conflict with one another and act more as obstacles to good water management than promoters. A complication is that many people do not recognize that institutions, rather than physical conditions, are often the cause of shortfalls in water supply. In fact, many physical problems cannot be overcome without accompanying changes in institutional elements. Water resources planners, developers, and managers must be aware of this; otherwise, their plans and designs may have little hope for realization.

3-1 NATIONAL WATER POLICY

United States water policy exists implicitly in numerous statutes, regulations, and administrative actions. It includes plans for flood control, navigation, fish and wildlife preservation, reclamation of arid lands, conservation, elimination of pollutants, recreation, municipal and industrial water supply, and other water-related features.

The Reclamation Act of 1902; the 1909 Rivers and Harbors Act; the Flood Control acts of 1917, 1936, and 1944; the Water Resources Planning Act of 1965; and the Federal Water Pollution Control Act amendments of 1972 and 1977 are a sampling of the pertinent federal laws.

Over the years, as national goals have changed, so has the nation's water policy. For the most part, redirections have been associated with

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piecemeal efforts, however, and new provisions have been layered over the old, often with little thought given to the inconsistencies created in the process.

Modern attempts (since 1970) to reshape water policy can be associated heavily with the recommendations of the National Water Commission (NWC) in 1973, with those stemming from President Carter's Water Policy Initiatives in 1978, and with the deliberations of President Reagan's Cabinet Council on Natural Resources and Environment (established in 1981) (1, 2).

The NWC stressed the need for a more direct embodiment of environmental considerations in water resources planning processes and embraced the principle that users should pay the full costs of water projects. It also emphasized the need for an aggressive effort to improve the quality of the nation's waters but believed that the nationwide uniform treatment provisions of P.L. 92-500 would not lead to the most rapid or cost-effective solution to water quality improvement. The NWC's analysis was comprehensive, and although it included many recommendations for action by the federal government, few of them have been implemented.

President Carter's water policy reform proposals were designed to improve water resources planning and management, to permit construction of sound water projects, to emphasize water conservation, to enhance federal-state cooperation, and to increase the focus on environmental quality (2). Although some changes resulted from this effort, studies and regulations were the main products and few new facilities to meet emerging water needs materialized. By 1980 the entire United States federal water program appeared to be suffering from a negative image. This was created partly by the environmental movement of the 1960s and partly by an emerging general belief, sometimes poorly founded, that most water projects were overpriced and of greater detriment to society than benefit.

The Reagan administration, like its predecessor, established machinery to consider water policy reform. The Cabinet Council was established and the Assistant Secretaries Working Group on Water Resources was set up to assist it. The early focus of these organizations was on reviewing the principles and standards for water and related land resources planning (P&S, see Chapter 4) and on developing revised cost-sharing policies to move toward full cost recovery for water projects where beneficiaries could be clearly identified. Fundamentally, however, the Reagan administration espoused the principle that the states should assume greater responsibility for the planning, design, construction, management, and financing of water resources projects. A transition from mainly federal to state responsibility in water programs is slowly emerging. This significant institutional shift has many problems associated with it, but one thing is certain: the states will have to develop a level of competency in dealing with water matters that in many instances is not presently (1984) apparent.

3-2 POLICY FORMATION PROCESSES

The management of water and other resources is carried out in accordance with policies set at various levels of government. These broad policies are exemplified by the following statements: provide adequate quantities of water for human needs, ensure the maintenance of good quality water, guard against the ravages of floods, and protect the environment. Such policies are translated into action by statutes, regulations, and administrative actions. The design of these policies and their plans for implementation are fundamental determinants of how the world's water resources are used and managed. The institutions discussed in this chapter are at the same time derivatives of water policy and constraints on forming new or revised policies. It is important that they be understood in this context.

Policymaking is an outcome of political forces operating in different political arenas. Conflict is an inherent element of these political processes, and it serves to ensure that a multiplicity of values is represented. Compromise is a partner to all policymaking and the art of reaching this compromise can be greatly enhanced by appropriate technological input and the use of state-of-the-art analytical techniques.

Water managers at various levels face local institutional frameworks that define and limit their actions. Where constraints appear overly restrictive, suggested policy changes should follow. Policy analysts, using the feedback from current management stances, can begin to shape new policy choices. According to Stokey and Zeckhauser, these choices may be made after the following process: establishing the nature of the issue to be dealt with, presenting alternative methods for addressing the issue, predicting the consequences of the suggested alternative courses of action, and placing values on the outcomes produced, monetary or otherwise (3). This procedural framework is well suited to a variety of modeling approaches such as those discussed later in this text. Important to the successful use of such models is the inclusion in them of the institutional constraints that limit what can be done.

The goal of the process to guide policymaking should be the provision of the best information given that time, basic data, and manpower may be limiting. Choosing among competing options is not easy, as the future is unknown, but by doing a better job of assessing the outcomes of various alternatives and establishing a mechanism for evaluating their consequences, better decisions and consequently policies should be the result. The reader should keep this in mind as he or she moves through the discussions on analytical methods that follow.

3-3 INSTITUTIONAL ISSUES

Water supplies are thought to be inadequate in many locations, and it is commonly believed that the only way to solve this problem is to tap new sources. In some cases, water availability is limited and technical solutions are appropriate. In other cases, the water is physically available but locked out of use due to laws, regulations, or other institutional mechanisms. Unfortunately, these institutional elements are sometimes hard to change because they may involve political sensitivities and may also be tied to local traditions. They are the heart of many water problems, however, and deserve attention accordingly. Institutional issues of importance include:

The nonuniform, incomplete, and sometimes conflicting coverage of state and federal water laws. At the federal level, Indian and federal reserved water rights issues are compelling. Uncertainties created by unquantified water rights may constrain planning and inhibit investments in water management facilities.

The failure of laws, agencies, and water users to recognize the interrelations of surface waters and groundwaters. The use of water from one source often affects the availability from another. Efficient regional water management cannot be achieved unless surface waters and groundwaters are used in a coordinated fashion.

The separation by statutes and administrative processes of water quality and water quantity. Water quality decisions affect water quantity decisions and vice versa, and yet they are often made without regard for one another.

The failure to recognize that water is not a free commodity. Users often pay far less than the cost of providing the water they use. Furthermore, fees collected for water services are sometimes channeled to purposes other than defraying the capital costs of new water projects or for meeting operation and maintenance expenses.

The focus on projects as opposed to comprehensive plans for achieving water resources goals. Historically approaches to water resources development have often been piecemeal and narrow in perspective. This has resulted in less than optimal regional systems of development and questionable federal investments in facilities.

The lack of effective national, state, and regional mechanisms for setting priorities for water resources investments. Good investment decisions require mechanisms to set water development priorities in the context of all options for water resources expenditures and within the broader framework of other needs for federal outlays of funds. The principal yardstick used at present is the project-oriented benefit-cost analysis.

The lack of mechanisms for ensuring implementation of plans. A great deficiency in water resources planning systems has been the inability of planners to influence decisions through their plans. If plans are worth developing, they should be used in decision-making processes.

The diffusion of legislative jurisdictions at all levels of government. Split legislative committee jurisdictions, for example, foster inconsistencies in programs, duplication of efforts, and conflicts in management.

The inability of federal, state, and local agencies to coordinate their programs.

The proliferation of regulations, many of which constrain rather than promote the effective use of the nation's waters. The construction of wastewater treatment facilities has been impeded, for example, by confusing regulatory requirements. Some requirements have been imposed retroactively in the middle of design procedures, adding millions of dollars to project costs.

The nonuniformity in requirements for evaluating water resources projects. Sewage treatment plants, for example, are not judged in the same manner as water storage works. Dams are subjected to detailed benefit-cost analyses whereas sewage treatment plants must only be cost-effective.

The variety of and sometimes conflicting purposes of state and federal water laws, the proliferation of water agencies, and the ill-defined roles of federal, state, and local governments are prime aspects of institutional elements that must be reckoned with and overcome. The enormous body of environmental laws and regulations that has been produced in recent years is also troublesome. The sometimes inconsistent interpretation of these laws and regulations by federal agencies and the courts has, for example, hindered the construction of even beneficial water projects. Furthermore, various laws and regulations have sometimes been used inappropriately as tools to derail or delay water and other types of development.

3-4 ROLES OF FEDERAL, STATE, AND LOCAL GOVERNMENTS

Basic to the resolution of many water problems is clarification of the roles of federal, state, and local governments in addressing them. In its 1973 report, "Water Policies for the Future," the National Water Commission stated that "development, management, and protection of water resources should be controlled by that level of government nearest the problem and most capable of effectively representing the vital interest involved" (1). The commission envisioned a continuing federal role in planning and financing but believed it should gradually diminish. The report also proposed that "Regional and State entities, as well as local units of government, should assume increasing roles in the control of water resource use and preservation."

President Carter's water policy reforms of 1978 included emphasis on an increasing role for the states (2); the Reagan administration has taken a similar position. Unfortunately, there has been little evidence to indicate how some of the states might be able to take on added burdens such as this along with their own fiscal problems and sometimes limited technical cadres. If a successful transfer of authority is to be made, some federal guidance and technical support will probably be required and innovative financing options may be needed to permit some of the less well-to-do states to carry on a determined effort.

3-5 STATE AND FEDERAL WATER LAW

Many of the laws that share in allocating this nation's waters came about as a result of local disputes and/or circumstances. At the time of their design, they were usually appropriate, but today many of them have outlived their usefulness and some even constrain efficient water management.

State Water Law

Water law in the United States is mostly property law and almost entirely state law with the exception of Federal Reserved Water Rights and Indian Water Rights, which are covered later (4, 5, 6). There is also a distinction between groundwater law and surface-water law, and this imposes an added difficulty for water managers. The extent to which these two legal systems vary is dependent on the individual state. It has been common practice, however, for states to use separate laws for groundwater and surface water even where the two systems are physically interconnected. Different rules sometimes apply to waters moving downward through the ground than for those already stored and moving underground. A particularly troublesome point is that rechargeable and nonrechargeable aquifers are often treated the same in state laws. In this case, the argument can be strongly made that the renewable segment of the groundwater resource should be treated differently from the nonrenewable or "stock" resource.

The interface between the hydrologic system and the legal system is depicted in Figure 3-1 (6). Hopefully, the trend in the future will be to bring legal systems dealing with water into closer balance with hydrologic systems. In particular, interactive surface waters and groundwaters should be managed conjunctively and water stored in aquifers having insubstantial mechanisms for recharge should be treated independently as a stock resource. In the meantime, planners and managers will have to deal with the legal systems that are already established. A good summary of the various state water laws was published by the National Water Commission in 1973 (7).

SURFACE-WATER RIGHTS

There are two principal doctrines regarding surface water in the United States (4, 5, 6): the surface-water rights system that prevails in the eastern

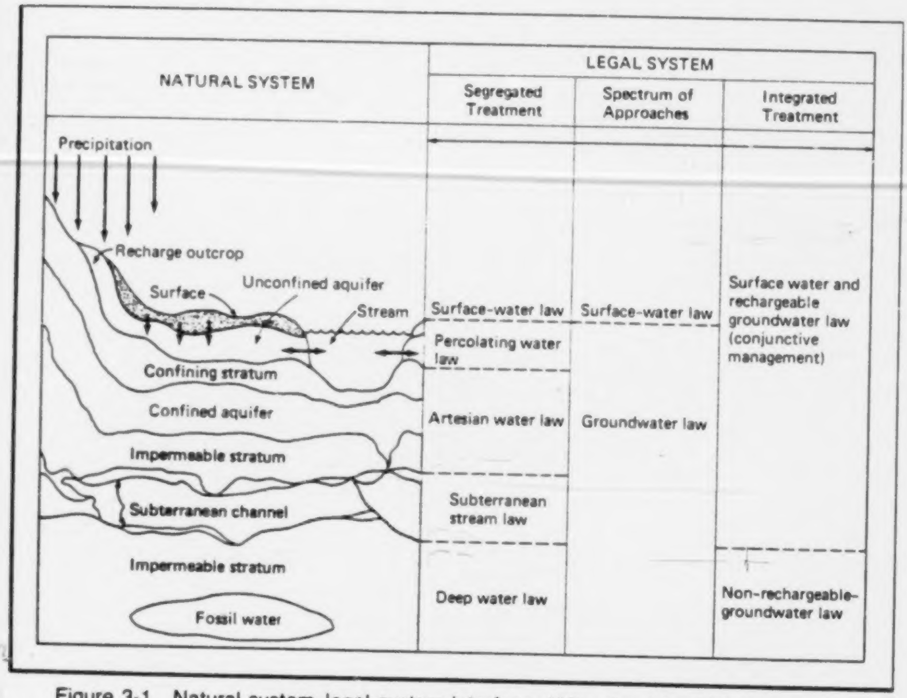
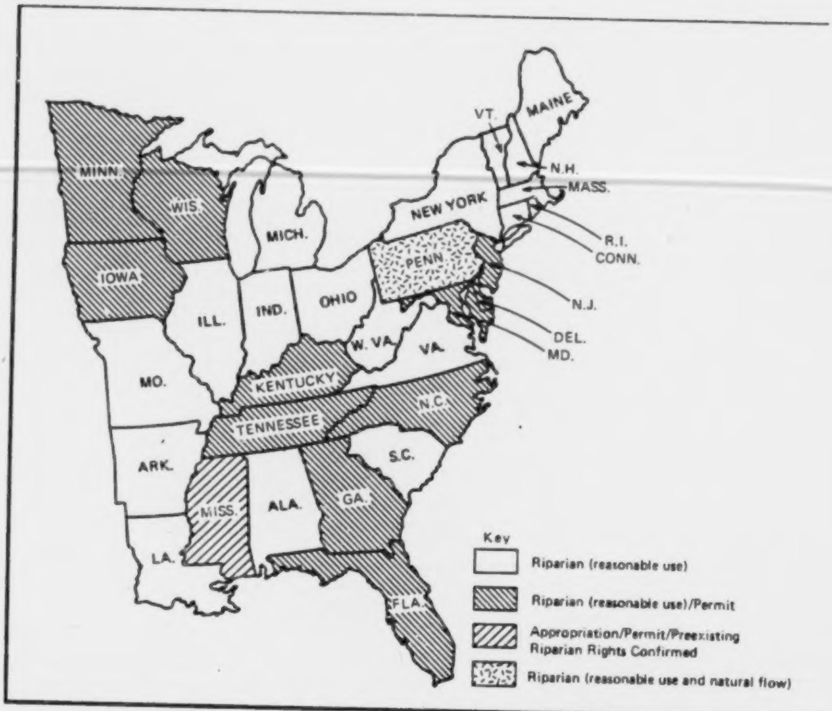


Figure 3-1 Natural system–legal system interface. (After the John Muir Institute, Inc., reference 6.)

United States is that of riparian rights, whereas the system of appropriation rights is the one generally followed in the west (Figures 3-2 and 3-3).

- *Riparian Rights.* Water law in the eastern United States was modeled mostly after the system that evolved in England. In that scheme, lakes and streams were considered as "private" waters and the right to use them was given the owners of "riparian land" (land that borders on, or encompasses, a surface-water system). The water was expected to be used for beneficial purposes and was not to be impaired in quality or diminished in quantity when returned to the source. This provision was considered to be overly restrictive for American practices, and in the eastern United States a doctrine of "reasonable use" was generally established. This doctrine permitted a riparian landowner to modify the quantity and quality of water withdrawn within the bounds of reason so long as the water was used for the purpose for which the land was dedicated.

Riparian water rights are generally obtained along with the purchase of riparian land. It is possible, however, for riparian land to be sold with a provision in the deed stating that the water rights are to be retained by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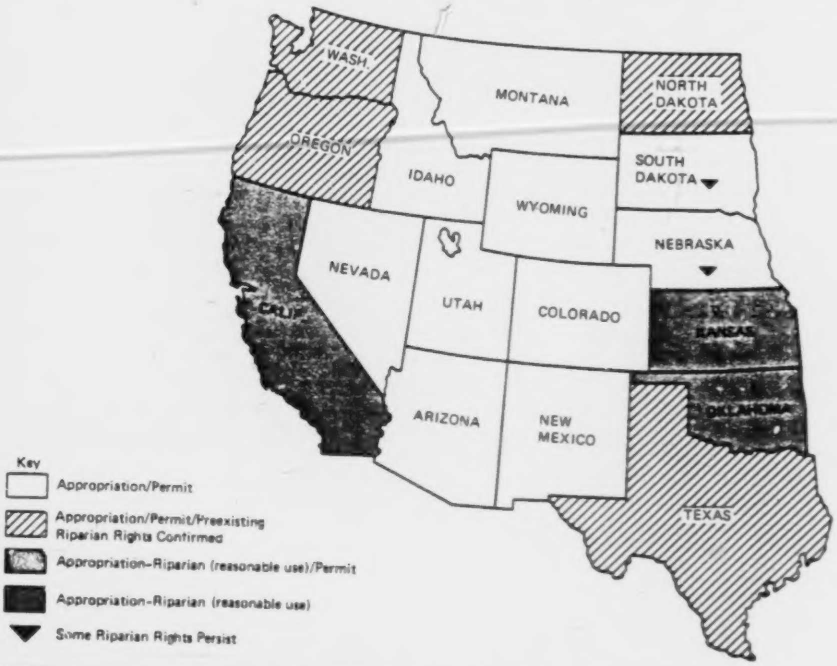
Key
☐ Riparian (reasonable use)
▨ Riparian (reasonable use)/Permit
▨ Appropriation/Permit/Preexisting Riparian Rights Confirmed
░ Riparian (reasonable use and natural flow)

Figure 3-2 Surface water rights systems in the eastern United States. (After the John Muir Institute, Inc., reference 6.)

the seller. Although tradition has been that riparian landholders are entitled to withdraw reasonable quantities of water whenever they desire to do so, many states are now beginning to impose permit requirements. When this is done, the riparian owner must secure a permit from an appropriate state agency before withdrawals can be made. Such permits are often conditioned to ensure noninterference with existing water users served by the same source and to ensure that adequate flows for instream purposes are maintained and that water quality is not impaired.

Riparian rights are usually considered to be coequal, that is, there is no priority assigned the most senior user. In times of shortage, all users are expected to curtail their uses on a pro rata basis. It is generally expected that riparian waters must be used on the owner's land, but there is usually no restriction placed on the type of use.

As water uses have increased and the number of withdrawal locations has grown, the tendency of riparian states to move toward permit systems has accelerated. Concern about maintaining adequate instream levels for fish and wildlife has been an important factor in bringing this about.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OKLAHOMA
ARIZONA
NEW MEXICO
TEXAS
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Appropriation/Permit
Appropriation/Permit/Preexisting Riparian Rights Confirmed
Appropriation–Riparian (reasonable use)/Permit
Appropriation–Riparian (reasonable use)
Some Riparian Rights Persist

Figure 3-3 Surface water rights systems in the western United States. (After the John Muir Institute, Inc., reference 6.)

Where permits are required, they may impose restrictions on where withdrawals may be made, on the quantities of water that may be withdrawn, and on the period of time over which the withdrawals may be made. In some cases, some uses may also be assigned a higher priority than others so that during times of limited supply, the users having the highest priority may be able to continue their operations uncurtailed, while other users may be required to limit their uses. Permits may also specify that the nature of a water use cannot be altered without approval of the water rights agency. All these modifications of the early riparian system have come about as water supplies have become more heavily used and their quantity diminished. The intent of the permitting system is to ensure that essential water uses are maintained during critical periods, that the quality of the water is protected, and that waste is guarded against.

· *Appropriation Rights.* The surface-water rights that predominate in the western United States are for the most part appropriation rights. In the early days of western settlement, the commonest enterprises were mining and agriculture. Both of these endeavors required large amounts of water, and the location of the water use was often not suited to the eastern riparian system, that is, the land under development was not always adjacent to a surface-water source. The appropriation doctrine was thus devised, permitting water withdrawals to be made and applied to lands for beneficial purposes regardless of the ownership of the land. The principal means by which appropriation rights may be obtained are demonstrating an intent to withdraw water for a beneficial use, actually diverting the water, and applying the diverted water to a beneficial use (6). Another distinguishing feature about appropriation rights is their priority system. Unlike riparian water users, appropriators are assigned a level of priority based on their seniority of water use. Thus the concept of "first in time, first in right" emerged. Basically, the idea was that the most senior appropriator could, during times of shortage, use the full amount of water to which he or she was entitled before the next senior appropriator could exercise his or her right and so on. Under this system it is therefore possible for junior appropriators to be left without water during critical periods.

Appropriation rights are generally obtained by applying to a designated state agency, and if the application is accepted, its date becomes the mechanism by which the priority is established. Permits are usually granted if they are found not to create conflicts with existing users, if unappropriated water is available, and if the proposed project is not in conflict with the public interest. A key aspect of the appropriation doctrine is the designation of what is considered to be a "beneficial use." Many water rights statutes term this the "basis, measure, and limit" of the right to use water (6). Historically, beneficial uses have been described as those uses having clear economic value. Generally these include uses for domestic, agricultural, industrial, mining, and municipal purposes. More recently, some states have defined nontraditional uses as being beneficial. In particular, several western states now recognize instream flow uses as beneficial. Some states also give preference to certain uses over others so that during times of stress, these favored uses will be satisfied even though their priority might be lower than that of another use. In most cases, preference is given to domestic and municipal uses and often to agricultural uses.

Once a right to use water has been obtained by an appropriator, he or she must exercise this right or it may be lost through nonuse. Thus the concept of "use it or lose it" was established. This is declared by many to encourage waste rather than conservation. The problem is that there is no incentive for appropriators to conserve since they cannot usually benefit from the water saved and may even be penalized if they forfeit the right to water they may desire to use in the future.

Appropriation water rights can usually be sold, although the new owner may be required to file for a permit if he or she wishes to change the nature of the water use or the place of use or withdrawal. In some states there are restrictions on using water outside of the basin of origin or outside of the state. Furthermore, some applications for change in water use may be refused because the state recognizes a preference for the original type of water use.

- *Weather Modification Rights.* Although weather modification is still in its infancy, California Pacific Gas and Electric and Southern California Edison have sponsored cloud-seeding operations. Legal problems associated with such practices are also emerging. Basically, these relate to the right to seed, the rights to the water generated, and the adverse effects of seeding operations on others.

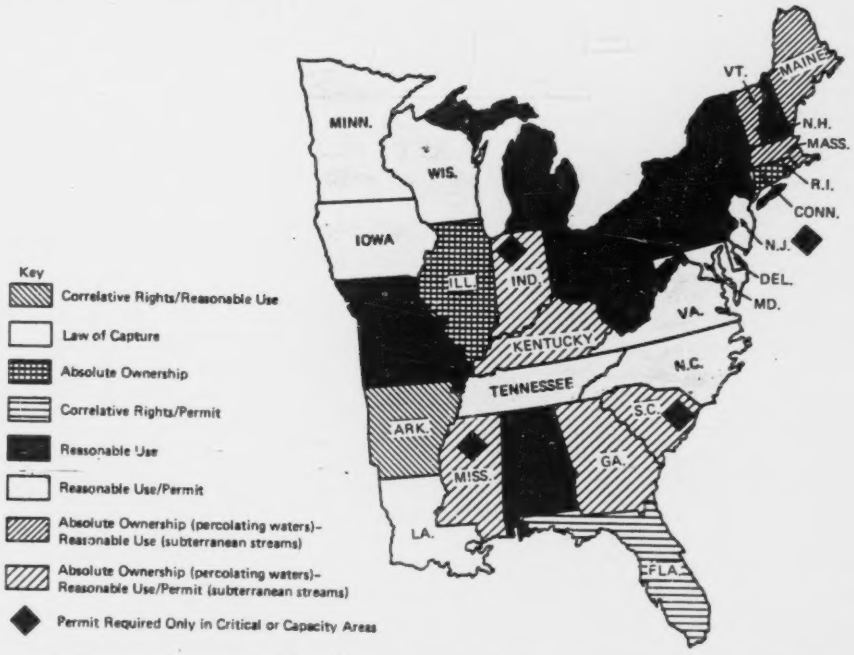
In 1978 the Department of Energy (DOE) reported that 33 states had laws relating to weather control (6). Only three states were known to have statutes allocating water rights from seeding operations; two of these followed the appropriations doctrine whereas the other one tied the rights to laws regulating natural precipitation (6). The legal aspects of weather modification will unfold as controllable systems appear and are put into practice. As this occurs, controversy and litigation are likely to be extensive.

GROUNDWATER RIGHTS

There are four doctrines applicable to groundwater rights in the United States (5, 6). These are the common law of unlimited withdrawals, the rule of reasonable use, the correlative rights rule, and appropriation rules (Figures 3-4 and 3-5).

Groundwater law is generally more local in dimension than is surface-water law and has been defined as having been heavily influenced by technological changes that have made possible an ever increasing facility in pumping and spreading water (5). One aspect of groundwater law, which makes it more complex to deal with than its surface-water counterpart, is that it is not consistently defined among the states. Various subdivisions are used, including channelized, artesian, percolating, tributary, rechargeable, and nonrechargeable (6). Another complication arises from the fact that under some circumstances, groundwater may be classified as "mineral" or "geothermal," subjecting it to a different set of laws entirely (6). The uncertainties created by these different designations make the groundwater management task all the more difficult. Furthermore, some localities have little or no mechanism for dealing with groundwater withdrawals and use, and this often leads to misuse and sometimes to conflict with surface-water withdrawals.

Where groundwater permitting systems exist, there may be provisions for perpetual use, subject to conditions on nonuse or wasteful use, or for use for limited periods of time. The latter arrangement is gaining in popularity and will likely be commoner in the future. Another feature of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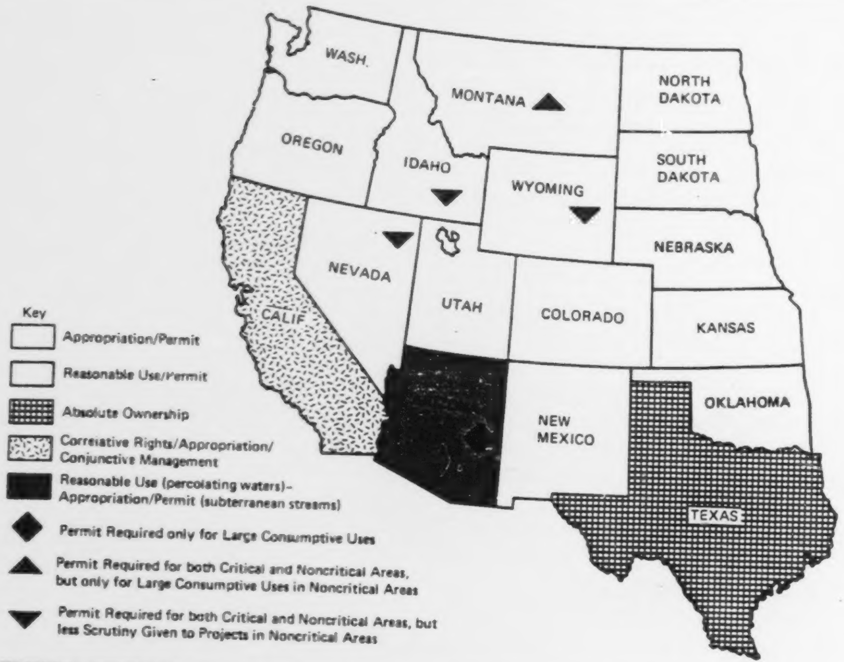
MD.
Key
Correlative Rights/Reasonable Use
Law of Capture
Absolute Ownership
Correlative Rights/Permit
Reasonable Use
Reasonable Use/Permit
Absolute Ownership (percolating waters)–Reasonable Use (subterranean streams)
Absolute Ownership (percolating waters)–Reasonable Use/Permit (subterranean streams)
Permit Required Only in Critical or Capacity Areas

Figure 3-4 Groundwater legal systems in the eastern United States. (After the John Muir Institute, Inc., reference 6.)

groundwater regulatory systems is the designation of critical or closed areas. Usually these are locations where the annual recharge from all sources is less than the annual withdrawal. These are circumstances usually referred to as "mining." If a state declares a "critical area," then it may regulate the number of wells in the area, limit pumping, and restrict new development.

- *Common Law.* In the common law system, an overlying landowner can withdraw groundwater in any amount for any purpose. This sytem was borrowed from English common law, that is, law that grew out of court decisions. Under the common law system there is no liability for damage to any other user of the same groundwater system. This means that a user can lower the water level to the extent that wells of other users might become useless without any fear of recrimination. In days when groundwater withdrawals were small, this was not important to consider, but in modern times, the technical ability to withdraw large quantities of water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CALIF.
OKLAHOMA
NEW MEXICO
TEXAS
Key
Appropriation/Permit
Reasonable Use/Permit
Absolute Ownership
Correlative Rights/Appropriation/Conjunctive Management
Reasonable Use (percolating waters)–Appropriation/Permit (subterranean streams)
Permit Required only for Large Consumptive Uses
Permit Required for both Critical and Noncritical Areas, but only for Large Consumptive Uses in Noncritical Areas
Permit Required for both Critical and Noncritical Areas, but less Scrutiny Given to Projects in Noncritical Areas

Figure 3-5 Groundwater legal systems in the western United States. (After the John Muir Institute, Inc., reference 6.)

from the ground emphasizes the need to properly evaluate the influences of these withdrawals on others and to provide reasonable safeguards.

- *Reasonable Use.* Under the doctrine of reasonable use, overlying landowners are considered to have coequal rights. This system, which also requires nonwasteful use, was established to counteract some of the more troublesome aspects of the common law doctrine.

- *Correlative Rights.* In this system, rights are allocated in proportion to the extent of ownership of the overlying land. The concept of reasonable use may also be incorporated. This doctrine has not found widespread use in the United States although it is used in California, Arkansas, and several other states (6).

- *Appropriation Rights.* The system of prior appropriation for groundwater is similar to its surface-water counterpart. In this case, a permit must be obtained from an appropriate state agency. This sets a priority based on time. Most states in the west follow the doctrine of prior appropriation, but there are exceptions. For example, Texas, a major groundwater user, follows the common law doctrine.

STATE WATER RIGHTS ISSUES

There are many inconsistencies in state water rights laws. Some of these constrain new water resource developments and inhibit or foreclose exercising the best available water management practices. In Nebraska, for example, water rights are specific to the type and place of use and this cannot be changed. In Colorado, on the other hand, water rights are separable from the land and may be freely sold or transferred. Third-party interests are another issue that is hard to deal with. What must be considered here are the possible consequences for harm to a third party by actions taken as a result of transfer of water rights from one user to another in which some change in use or point of withdrawal of use occurs.

In the east, common law water rights doctrines often forbid the transfer of groundwater from overlying land, and where surface-water use is regulated by permit systems, similar restrictions are also common. In theory, at least, many western states can accommodate water rights transfers. This does not mean the same thing in all states, however, and even transfers that are legal are sometimes difficult to implement (4).

Some common constraints that have bearing on the acquisition and use of water for various purposes are the following: restrictions on groundwater mining; restrictions on off-site use; prohibition of transwatershed export, restrictions on interstate transport of waters; provisions protecting other water rights; preferential treatment of some beneficial uses; restrictions on type of water use; antispeculation prohibitions; uncertain status of deep groundwater, saline groundwater, and geothermal waters; and uncertainty concerning the use of aquifers to store, transport, or comingle artificially recharged waters (6).

There are many approaches that might be taken to deal with constraints imposed by water laws. These include legislative change, court action (often not a preferred approach but sometimes the only option), providing reliable data to reduce uncertainty, agreeing to compensate injured parties, augmenting water supplies, improving water quality, mitigating impacts, substituting new water uses for old ones, regulating rates of withdrawal of groundwater, metering water use, and developing educational programs.

Many water laws are coming under scrutiny as legal constraints on water development and use arise. According to one recognized authority on water law, Frank J. Trelease, the ideal system of water rights should promote efficiency in water use by providing "both security and flexibility of water rights" (4). This means that holders of water rights should be given sufficient tenure in their rights so that they will not be hesitant to make needed investments in facilities. At the same time, there must be a mechanism for shifting from low production to high production uses when this is considered necessary.

The foregoing ideals could be achieved in several ways. One approach would be to develop a system of administrative allocation. In this case, the water to be allocated would be put in the hands of an administrator who would make decisions about how and where it should be used. Alternatively, changes could be made in the appropriation doctrine to permit needed transfers and reallocations of water during critical periods and to guard against waste. Trelease cautions that care would have to be exercised in using the administrative approach because it might unduly focus power in the hands of a single individual. Either system could be designed to incorporate the features considered important to a region's water management. In the future it is likely that modified water rights systems will incorporate some elements of each.

Federal Reserved Water Rights

National parks, national forests, and other federal lands withdrawn from the public domain have rights to sufficient water to serve the purposes for which the reservations were intended. This doctrine was enunciated in the 1955 *Pelton Dam* decision by the U.S. Supreme Court, *Federal Power Commission v. Oregon,* 349 U.S. 435 (1955), and reaffirmed by *Arizona v. California,* 373 U.S. 546 (1963).

If federal reserved rights are not quantified, planning for future water allocations becomes uncertain, and needed developments might be delayed or forgone because developers fear that the exercise of the federal right at some future time might restrict or destroy their proposed operations. A priority is assigned the federal right based on the date the reservation was created, and since this might predate a more recent application for a water right from the same source, the potential for conflict is easy to see. As of 1980, adjudication (explicit determination) of federal reserved rights had not been extensive.

Originally, the notion of federal reserved water rights applied only to Indian reservations. Later, the doctrine was extended to land reserved for national forests, parks, and recreational areas; for national monuments; and for wildlife refuges (6). Reserved water rights may involve both surface water and groundwater. Only waters unappropriated at the time of the reservation are affected, however, and the federal government must compensate for damages to those holding rights predating those of the reservation.

Key issues are the quantity of water to be reserved and the use to which it is to be put. A 1978 court decision (U.S. v. New Mexico) held that reserved water may be used only for the original purpose of the federal reservation. This finding narrowed the scope of the reservation doctrine, and in so doing removed some of the uncertainty associated with the doctrine. One other modifying influence on the doctrine is that the determination of federal reserved water rights may be made in state courts (6). The fact that recent legislation and court decisions tend to restrict the reservation doctrine is of great importance to the states. A broad interpretation of the reservation doctrine could lead to confrontation with state constitutional or statutory provisions and generally interfere with the operation of state water rights systems. By integrating federal reserved water rights into existing state water rights systems, the limit of the rights can be determined and planning uncertainties can be minimized.

Indian Water Rights

Indians have been settled on reservations that were set aside for the purpose of promoting agriculture and "civilization." In the arid west, the lands of most of the reservations were considered to be of little value unless water was provided. This basic concept of Indian water rights was established in law by the 1908 case of *Winters v. United States,* 207 U.S. 564.

Indian water rights under the Winters doctrine are separate and distinct from water rights established under the prior appropriation concept used in most western states. Indian water rights arise in federal law and generally are established at the time a reservation is created. When the reservation is on lands aboriginally owned by the Indian tribe, the water rights may be considered to exist from time immemorial (1). Ordinary appropriated waters have a priority in time dating to the time of first use or from the date of a permit whereas Indian rights have a priority in time dating at least to the date the reservation was established. Indian reservations considered to have aboriginal rights would have first priority on the body of water serving their supply.

On a historical basis, the amount of the water right would seem to be sufficient water to satisfy agricultural and related needs. Thus far, there has been only one major adjudication of the Winters doctrine rights. This was by the 1963 *Arizona v. California* decision, 373 U.S. 546, which paved the way for authorization of the Central Arizona Project. The decision in that case was that the five central tribes of Arizona had the right to sufficient water to irrigate all the "practicably irrigable acreage" on their reservations. Future adjudications may face a variety of issues such as the eligibility of municipal and industrial needs for water rights, the ability to use irrigation-based rights for other purposes, and whether the water rights should be permanently fixed or allowed to change with the times (8). The amount of water needed to irrigate acreage practicably appears to be the principal component of the Winters doctrine rights, however.

The competition between Indian and non-Indian water rights poses some significant problems, especially in the west. Most Indian reservations predate major water projects in that region, although heavy use of water by the Indians has generally developed in relatively recent times. An important factor to be dealt with is that the resource potentials of Indian reservations are often large. In the northern Great Plains, for example, most Indian lands are underlain with hugh reserves of coal and other valuable minerals, many have outstanding recreation features, and many contain large areas suitable for agriculture. The tribes are concerned that water used for non-Indian purposes will adversely affect their water rights and lead to depletions on their reservations. They seek assurances that their water requirements will be fairly considered by those outside the Indian community. Although many studies have addressed the issue of Indian water use, the fact remains that the quantities of water needed are generally unknown or are in dispute. Until this matter is resolved, uncertainty will surround plans for future water allocations, and even the maintenance of existing operations at current levels may be subject to question.

Interstate and International Water Law

There is no general federal policy regarding interstate and international waters, but there are devices available to resolve questions of water quality or water allocation among the states or between the United States and Canada or Mexico. For international issues, the usual approach is by the use of a treaty. Examples are the Mexican Water Treaty of 1944, which provides for Mexico's share of Colorado River water, and the Boundary Waters Treaty of 1909 with Canada, which allocates waters of the Milk River.

Means to allocate and manage interstate waters are interstate compacts, Supreme Court litigation, and congressional allocation (9). The most widely used of these instruments is the compact. Compacts can be used to allocate interstate waters, to regulate water quality, and for other purposes. As of 1977, there were 35 compacts in force dealing with various aspects of water management (9). These include the Colorado River Compact of 1922, the Rio Grande Compact of 1938, the Potomac River Basin Compact of 1940, and the Delaware River Basin Compact of 1961(10).

3-6 REGULATIONS

Once a new agency or program is established by law, regulations pertaining to its purpose are drawn up. In the early part of the twentieth century, this was not especially troublesome, but today the number of laws and their accompanying regulations sometimes pose formidable obstacles to those they are intended to guide (11).

A good many of the policy conflicts and added costs due to regulatory requirements can be traced to the rapid expansion of environmental law that took place after the environmental movement of the 1960s. Although recognition of the need to provide adequate and reasonable safeguards for the environment was probably long overdue, the zealous efforts that took place in the late 1960s and early 1970s were unfortunately often uncoordinated and in some cases poorly thought out. The result is that today there are thousands of legal and regulatory measures that affect all aspects of water resources development and management and, contrary to their original intent, they sometimes confuse, delay, and limit our ability to achieve the most efficient solutions to water and related problems. It has been said that the current laws are too complex, too inflexible, and constructed so as to foster procedural complexities (12, 13).

Some idea of the scope of this issue can be had by considering that the 185-page Clean Air Act has generated over 2500 pages of regulations to implement it. The Clean Water Act, which is about 125 pages in length, has an associated compilation of regulations that exceeds 1200 pages. It has been reported that "no one at EPA headquarters fully understands even a single program . . ." (13).

Regulatory reform is needed, as is a new approach to environmental law that recognizes regional differences, permits alternative solutions rather than requiring a uniform fix, assesses the likelihood of practical compliance, and accepts the premise that methods other than new laws may sometimes be more efficient for solving environmental problems. According to Orloff, what is needed is "a set of guiding principles, clarity, straightforwardness, consistency, knowledge of the intrinsic limits of legislation, and a solid informational base . . ." (13).

The point is that a balanced approach to environmental protection is needed, one that permits attainment of environmental objectives while at the same time permitting the use of the most efficient technologies and procedures for achieving them.

3-7 TRADITIONS AND SOCIAL CUSTOMS

While laws and regulations directly influence actions taken with respect to water resources, traditions and social customs play a more subtle but no less important role. In the United States there are a number of factors that give rise to local practices and traditions. These include the historical dominance of a water use (irrigation in the western states), farming practices, climate; federal subsidies, the nature of the water storage and distribution systems that are in place, the cost of water, the nature of industrial operations and plant designs, the desire to maintain local or individual control of water and/or other natural resources, and resistance to change. In a worldwide setting, especially in developing or undeveloped regions, endemic religious traditions may be very influential as well. Planners confronted with the task of providing water that is safe to use and of ample quantity to satisfy the expanded needs of present users and needs of new users must be careful to see that their proposals will gain local acceptance and fit the character of the region to be served. If this is not done, there may be little hope of securing the necessary funding for the works envisioned. Furthermore, even if financing is available, facilities having features considered objectionable on religious or other grounds may not be used.

3-8 ORGANIZATIONS

One would have to return to very primitive times to find a period in which some significant conflicts in water use were not apparent. The resolution of these combined with the need to provide water to a variety of users has led to the development of an extensive system of organizations at all levels of government. Many of these organizations arose from a single need and were not designed to consider closely related or inextricably linked aspects of the water resource. This narrow special-interest focus has resulted in literally thousands of agencies and governmental units with responsibility for some facet of water resources development, management, or control. Many of these entities were well conceived at the time of their formation but have long since outlived their usefulness or ability to perform their functions effectively. The situation is parallel to that of the manner in which federal, state, and local laws have evolved over the years. The unfortunate aspect of all this is that there are few examples where existing organizations or laws have been eliminated as a first step in introducing new ones more consistent with the times. As a result, great inconsistencies, inefficiencies, duplications, and conflicts have been the product. The fundamental question is: What are the organizational needs for optimum water resources planning, development, and management? Associated questions are: What are the options for consolidating and/or eliminating existing organizations? and How can the many activities of these organizations, operating at all levels of government, be coordinated so as to minimize conflict and facilitate good water management? Answers to these questions have been sought for years, but many proposed mechanisms for achieving an efficient level of management or control have been difficult to implement due to strong intergovernmental and interagency jealousies and mistrusts. Those who are responsible for planning, constructing, regulating, and operating water resources systems must be able to face the prevailing organizational systems and develop workable policies for functioning within them if changes in these structures cannot be made (14, 15, 16).

Regional

Since the early 1900s, many commissions have considered the merits of regional or river basin organizations to carry on water resources planning and other related functions. The notion is still strong that regional, in addition to state and local, perspectives are needed if wise decisions are to be made regarding federal investments in water resources projects and programs.

The first and perhaps best known of the regional organizations is the Tennessee Valley Authority, which was established in 1933. The TVA is a public corporation created to "improve the navagability and provide for the flood control of the Tennessee River; to provide for reforestation and the proper use of marginal lands in the Tennessee Valley; to provide for the agricultural and industrial developments of said valley; to provide for the national defense by the creation of a corporation for the operation of Government properties at and near Muscle Shoals in the State of Alabama." The TVA has had a long and successful history, but it is unique in form, and not likely to be duplicated (10). The strength of the TVA stems from the fact that the organization has broad operating, management, and regulatory functions.

After 1945 the federal Interagency River Basin Committee program was established, which encouraged the creation of informal, voluntary interagency committees. Three of these, the Arkansas-White-Red, the Southeast Basins, and the Pacific Southwest committees are still in operation. Three others became the Pacific Northwest, Missouri, and New England River Basin commissions. These three have now been abolished. The interagency committees have little power and their main accomplishment has been in providing a forum for communication among the several state and federal agencies and units of government involved.

In 1961, the states of New York, New Jersey, Pennsylvania, and Delaware joined with the federal government in creating the Delaware River Basin Commission. Like the TVA, the DRBC has broad powers, which include both planning functions and implementation and operation. In theory, the DRBC has the power to do much more than it has done, but it has been very successful in settling disputes over water allocation among the participating states. As pointed out by Derthick, "a coordinating organization will work only to the extent that the participants share an interest in making it work" (10). One other commission designed along the lines of the DRBC has been formed: the Susquehanna River Basin Commission, established in 1973. The DRBC and SRBC are state-federal compact commissions and their creation requires a consensus of the states who would be participants. Many such compact commissions have been proposed, but a lack of consensus has stifled all efforts other than those for the Delaware and Susquehanna.

The most recent type of river basin organization grew out of the Water Resources Planning Act of 1965. These were the Pacific Northwest, Missouri River, Upper Mississippi River, Great Lakes Basin, Ohio River, and New England river basins commissions. These RBCs were designed to be planning-coordinating entities and forums where representatives of states and federal agencies could coordinate activities and jointly develop river basin or regional plans for water and related land resources. They had no management or operating authority and did not replace functions of the federal agencies.

An independent chairperson, appointed by the president, coordinated the activities of the commissions. Each federal agency with an interest in the river basin was entitled to membership, as was each state lying totally or partially within the basin. The act provided that every reasonable effort be made to arrive at a consensus on all issues.

Creation of an independent chairperson and staff, divorced from federal and state agencies, was an important departure from the rotating chairships of predecessor interagency committees. It provided a loyality to the institution and an opportunity for focusing on regional goals rather than on the narrower objectives of the member states and federal agencies. A lack of control over members limited this authority, however.

The performance of the RBCs was hampered by budgetary constraints, problems of coordination, lack of authority to enforce decisions, and the necessity to act through consensus. Obligations of members to their parent organizations, the voluntary nature of the coordination process, and the limited capacity of members to speak for their organizations added to the difficulties. The result was that the RBCs fell short of expectations and on July 28, 1981, they were abolished.

The former RBCs have been reshaped into various forms of interstate entities charged with coordination of interstate activities and water resources planning. How long these organizations will survive is hard to predict, as is the role they will play in future decision-making processes in their regions.

It seems clear that interest in regional efforts is still high but that politically acceptable regional institutional arrangements are elusive. Furthermore, it seems that institutional arrangements will have to be tailored to suit the region. Experience shows that what will work in one place will not work in another, and that the imposition of uniform rules or systems nationally is doomed to failure.

State, Federal, and Local

Federal agencies involved in water programs have played significant roles in determining the types and locations of water developments that have taken place. The principal construction agencies, the Corps of Engineers, the Bureau of Reclamation, and the Soil Conservation Service, are still very influential. The major regulatory agency, the EPA, has become a dominant factor since the early 1970s in terms of both federal budget and the influence of its regulations on all aspects of water use and development.

Most states have agencies that are, in some ways, counterparts of the federal agencies. This has come about since the states have needed institutions to manage the many diverse federal programs in which they desire to participate or are required by law to be a party to. The water agencies of some states such as Texas and California have large expert staffs, but others depend for assistance on technical matters from appropriate federal agencies. The western states in particular have agencies charged with administering their water rights systems. Where permits are required in the east, a similar situation exists. The details of the wide variety of state agencies cannot be treated here. The important point to remember, however, is that they must be dealt with by those engaged in the water resources profession and a knowledge of them is a prerequisite to performing most jobs successfully. Another feature to be kept in mind is that state, federal, and local agencies and organizations may have powers ranging from comprehensive (planning, constructing, and managing) to very narrow, encompassing only such functions as planning, or coordinating, or issuing of permits. Agencies with wide-ranging powers offer the attraction of minimizing the number of entities that must be dealt with but have the drawback of minimizing checks and balances.

At the local level there are also many organizations that manage or relate to water programs. These include municipal water and sewer departments, local planning units, special-purpose local districts, and local agencies for health and environmental control.

Other Organizational Arrangements

In recent years, the problems of fragmented interests in water problems in many states and the extension of problems beyond the jurisdictions of some governmental units has led to the consolidation of organizations and the emergence of new authorities having capabilities for managing some aspect or aspects of water over an intergovernmental region. Two such endeavors will be presented here. They are the formation of consolidated natural resource districts in Nebraska, and the Southwest Florida Water Management District designed for flood control and water management over a 10,000 square mile area of Florida.

NEBRASKA NATURAL RESOURCE DISTRICTS

In 1939 there were 172 special-purpose entities in Nebraska designed to deal with some aspects of the state's waters (17). As greater demands were placed on this resource, additional governmental units emerged to address special needs. By 1969 the number of such organizations had grown to about 500. The result was a host of narrowly focused organizations, overlapping responsibilities, duplication of services and taxation, and limited ability to cope with problems encompassing more than one jurisdiction. There were about 15 types of organizations that had been authorized by the state legislature. These included soil and water conservation districts, watershed conservancy districts, watershed districts, watershed planning boards, irrigation districts, reclamation districts, sanitary drainage districts, drainage districts, and groundwater conservation districts.

To provide a better focus on solving the state's water problems, the legislature determined that a consolidation of these many districts would be needed and that a new set of regional water management districts should be devised to blanket the state. Action was taken in 1969 when the state legislature established 24 natural resource districts (NRDs). It was the intent of the legislature to create governmental units with sufficient powers to address a broad range of natural resources issues and to implement programs or projects to resolve them. Although only about 300 of the previous districts were merged or abolished in the process of setting up the NRDs, the new organizations had much greater capacity for managing water and other natural resources than their predecessors (17). The original intent of the NRD movement was to bring about a total consolidation of existing entities. This was not politically feasible at the time and so a compromise was struck. Nevertheless, the remaining districts were encouraged to cooperate and if possible to merge with the NRDs. In addition, the legislature specified that no new districts of previous form could be established after the passage of the legislation.

The supervisory control of the NRDs is vested in the state's Natural Resources Commission. This semiautonomous agency has broad powers and is charged with the task of coordinating the activities of the NRDs, other state agencies responsible for some aspect of natural resources, and other substate entities including counties, municipalities, and those special-purpose districts that were not abolished or merged into the NRDs. The principal state agencies to be dealt with are the Department of Water Resources (responsible for administering the water rights of the state), the Department of Agriculture, and the Department of Environmental Control (the state's counterpart to the EPA). The Natural Resources Commission (NRC) must also interface with those federal agencies whose programs apply to various aspects of developing and managing the state's waters. Even with the consolidation brought about by the formation of the NRDs, there are still many federal, state, and local agencies or units of government that must be dealt with. The NRC is thus faced with an important role in coordinating these units and their activities.

In establishing the NRDs, the Nebraska legislature gave them broad responsibilities. These include soil conservation and erosion control; flood and sedimentation control; water supply; development and management of groundwaters and surface waters; solid waste disposal, sanitary drainage, and pollution control; drainage and channel improvements; and responsibilities relative to fish and wildlife habitats, recreation, forestry, and range management.

In keeping with the assignment of many areas of responsibility, the legislature did not overlook providing the needed authority to get the job done. The powers of the NRDs include taxation; eminent domain; construction and maintenance of facilities; acquisition and disposal of water rights; financial assistance for projects; regulation of groundwater use; development, storage, and distribution of water; regulation of land use in certain cases; rate setting for water furnished; development of facilities for solid waste disposal; provision of technical assistance; assignment of charges to beneficiaries for services; and initiation and conduct of studies.

While the NRDs may obtain rights, they have little real control over surface water or groundwater allocations. The rights to divert waters are administered by the Department of Water Resources. In addition, the quantity and quality of streamflows are largely determined by the Department of Environmental Control and the state's Game and Parks Commission.

One of the advantages the NRDs hold over their predecessors is that of dimension. On the average, the NRDs are about four times larger than the average Nebraska county. This scale gives the NRDs the financial capability to obtain qualified technical staffs. Furthermore, the NRDs have access to a state resource development fund that may be used to fund or partially fund meritorious state projects. The size of the districts also suggests that many localized problems can be resolved within the bounds of a single NRD (17).

On the negative side, it has been argued that the choice of watershed boundaries was not wise, since most NRDs cover only parts of a basin. More importantly, because most state data are reported on a county basis, many believe that aggregations of counties would provide better limits of operation (17). The fact that not all of the special-purpose districts existing before the NRD legislation were disbanded or merged with the NRDs is another weakness. This is important since some of these other districts, the irrigation districts, for example, are powerful in their own right and thus dilute the authority of the NRDs.

Regardless of some of the weak spots, the NRD movement in Nebraska has much to recommend it. The NRDs are acting to facilitate coordination and are becoming a recognized force in dealing with intrastate water problems. The essence of the NRD model is sound and could be transferred to other states having a highly fractured approach to water management such as was in evidence in Nebraska in the late 1960s.

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

It is almost a universal rule that decisive political action relative to water resources management follows some period of crisis. So it was with the formation of the Southwest Florida Water Management District (SWFWMD). The legislation that created the district followed widespread flooding in Florida, which resulted in deaths and injuries and damages of about $200 million (18).

The SWFWMD is a regional flood control and water management regulatory agency. It covers about 10,000 square miles centered around the Tampa–St. Petersburg metropolitan region. The district was created in 1961. Its responsibilities have progressed from sponsorship of flood control projects to groundwater regulation, issuance of consumptive use permits, and management and storage of surface water (18). The district, which is now one of five similar districts that blanket the state, is governed by an unsalaried board that has taxing authority.

The governing board consists of nine leading citizens appointed by the governor and confirmed by the state senate. This board sets district policy, carries out regulatory responsibilities, enters into contracts, and authorizes tax levies. The district is subdivided into nine watershed basins. These basins generally follow hydrologic boundaries and all have their own basin boards except one. That basin, because of its special importance, is controlled by the district's own governing board. The basin boards are action oriented and may initiate projects to solve water problems. They also levy the necessary ad valorem taxes to support their budgets. The basin boards do not have the authority to regulate, however; that is retained by the governing board.

The taxing authority of the SWFWMD is substantial. Based on 1980 figures, tax revenues could have totaled about $28 million, although this level of assessment was not considered necessary and the income was closer to $7 million (18).

In 1974, legislation was passed in the Florida legislature allowing the establishment of regional water supply authorities. These authorities may develop, store, and transport water for sale to cities and counties. Concurrently the same act authorized the water management districts to plan, design, construct, and operate regional water supply facilities, but only if requested to do so by a county, city, or regional water supply authority. The effect of this action by the legislature was to add the potential for additional substate entities rather than vesting this authority totally in the hands of the water management districts.

A recognized strength of the district is that by having a responsible unpaid board as the executive head, a high degree of insulation from political pressures is evident. Furthermore, the nature of the board is such that maximum familiarity with local problems is achieved. Other advantages of the water management districts are their taxing authority; transcendence of local political boundaries; and capability to conduct studies, develop solutions, prepare plans and to design, construct, and operate water management systems. Weaknesses of the district system include lack of authority to plan and implement water supply projects unless invited to do so; lack of authority to regulate water quality; and lack of authority to construct, operate, or maintain sewage treatment facilities.

The district has compiled a good record of dealing with water issues in the region for which it has authority. Like the NRDs, there are limits to responsibility that keep the SWFWMD from attaining the theoretical maximum level of coordination. Even so, the district exemplifies another effective move at the substate level to reduce conflicts in water management, to minimize overlapping areas of responsibility, and to provide institutions capable of seeing their plans through to completion.

3-9 POLITICS

The political aspects of water resources development and management are probably the most difficult of all to deal with. They are very important, however, since almost every major decision dealing with public facilities is reached in the political arena. The political processes are complex, ever changing, and subject to high levels of emotionalism. In the final analysis, political feasibility determines the nature of actions that are taken.

The Decision-Making Arena

Politics may be considered the art of maneuvering to gain a particular objective. In the field of water resources, political decisions at all levels of government affect water availability and use. The city council makes recommendations regarding expansion of the city's water treatment plant, the governing board of an irrigation district considers regulating groundwater withdrawals, the governor of one state joins with that of another to seek an interstate agreement, and members of Congress respond to requests from their constituents for new water supplies. Whenever decisions related to the public interest and public investments must be made, the political process is called into play.

While it is hardly possible to address more than a few aspects of the political process here, it is instructive to give some examples of the complexity of the process, the many decision points, and the roles of various actors. In the realm of federally funded water projects or projects that are at least partially supported by the taxpayer at large, a system has evolved of first obtaining authorization for the project and second of obtaining appropriations to implement the project. This authorization and appropriations process involves individuals, groups, agencies, governmental units, and others in making choices in a variety of settings (19). Local interests envision the need for some type of water project or program and then devise a scheme to generate enough political support to bring their project to fruition. In the process, a given proposal may be considered and reconsidered at many levels before it finally reaches Congress for consideration. If congressional action is favorable, the bill will be passed on to the president for signature or veto. The time scale of this process may be 20 or more years for major projects, and during this period the project proponents will likely face many obstacles and can expect frequent periods of frustration.

The Congress of the United States authorizes the construction of water projects in response to political demands for them. Water projects usually distribute benefits directly to congressional constituencies while indirectly allocating costs. Thus the political rewards for bringing home a project are easily accounted for while the costs are diluted through funding mechanisms. The costs of a water project that has its major benefits in Colorado, for example, might be shared by taxpayers nationwide. Congressional selection has been strongly influenced by the desire to accommodate local constituencies. Unfortunately, this is not always compatible with building either the best or the most needed projects.

Proposals to construct water projects that are sent to Congress for consideration are referred to appropriate authorizing committees for review. Projects having social merit and obvious political support are usually received with favor. While economic and environmental selection criteria are important factors, strong political support at state and local levels is essential for positive action (19).

After a project has been authorized, funds for it must be appropriated if it is to be implemented. Congressional appropriations committees review project authorizations and determine which of these are to be funded and when. Thus obtaining project authorization is only the first part of the political process that must be successfully navigated if a project is ever to materialize. The political backing of project proponents must be powerful enough to pass both of these congressional hurdles.

The executive office of the president also plays a role in water project and program selection. In this case, the Office of Management and Budget (OMB), representing the president's position, reviews agency recommendations for new water projects and/or programs. Agency recommendations not conforming to OMB's interpretation of the administration's views are opposed. Based on OMB views, as well as on those of other policy officials of the executive office of the president and those of the agency heads themselves, the president decides which water projects he will recommend to Congress for funding. A project included in the president's budget is not assured of funding, however, as members of the appropriations committee might oppose it. In a like manner, a project not included in the president's budget might still be included in the budget bill by Congress if it is supportive. Obviously, project proponents must be prepared to convince both Congress and the administration if they are to be successful in their efforts.

Since the environmental movement of the 1960s, the traditional support for water projects has been eroding. It is becoming more and more difficult to assemble the coalitions needed to provide the political strength to implement any but the most socially and economically desirable projects. With this trend it is likely that some changes in project selection mechanisms by Congress will also take place. Even so, political rationale rather than technical judgment will still be the determining factor in the decisions that are made.

In an excellent study of political aspects of water resources development, Helen Ingram made a detailed analysis of New Mexico's role in the bill authorizing the Central Arizona Project (CAP) (20). Some of her findings are presented here as examples of the vagaries of the politics of water. The report deals mainly with two water projects in New Mexico that were included as part of the congressional package authorizing CAP.

The Ingram report noted that the inclusion of the two New Mexico water projects in the bill was "a curious event." It was said that the connection between the New Mexico projects and CAP was neither direct nor clear. Furthermore, it was pointed out that the effects of the two projects on CAP were detrimental. The report concluded that: "In terms of hydrology and engineering, economics and financing, the association of these projects in a single package appears irrational; its rationale appears only when the politics of the Colorado Basin Act are laid out." The role played by New Mexico in bringing this about was considered to underscore the overriding importance of political feasibility in setting water policy.

In the case of the CAP bill, local activists in New Mexico exerted considerable pressure to influence the political process at the most significant level. This was achieved by convincing Congressman Aspinall of Colorado that it was to his advantage to move quickly on one of the projects of interest to New Mexico (Animas-La Plata). Another political mechanism for consent-building, the practice of noninterference, also came into play.

In the case of CAP, its supporters were concerned mainly with whether the inclusion of New Mexico's demands would result in building added political support for the package that had CAP as its core. The Ingram study showed that where such political feasibility was found to exist there was no further questioning. This is the political technique of avoiding conflict by accommodating polar interests without confrontation. The idea is to "live and let live." Another finding of the analysis, and one of great importance today, was that activists who did not share the basic local concern about water were very hard to accommodate. The idea of mutual noninterference is not applicable to conservationists or environmentalist factions. It has become increasingly clear, however, that the views of these groups are having a much greater impact on the traditional game of water politics. This adds considerable time and difficulty to consent-building processes and may ultimately lead to changed perceptions and altered political patterns (20). The Ingram study also commented that even after CAP was taken up in earnest, it still took three Congresses and over five years to pass the bill. In view of today's concern about environmental and economic issues, it is not likely that another massive water project such as the CAP could make it through the political hurdles even that easily, if at all. Finally, it must be observed that while the rationality of water policy may be questioned on technical and other grounds, it is, in fact, politically rational. It represents the net effect of risks and rewards associated with the issues (20).

Political Constraints

The political process is one of consent-building to the level needed to gain support of Congress, a state legislature, or a local governing body. For each activist supporting a proposal and for each level of interaction there may be a counteractivist and an equal opportunity for interaction. What is meant here by interaction is the interface between the activist and those institutions in the political system where sufficient authority resides to make policy. The actions taken by those opposing a project or program thus may be considered as political constraints. These political constraints can be formidable and may in many cases be the determinant of the outcome of a given proposal. They may be defined as that class of institutional constraints stemming from the deliberate action of factions seeking to delay, inhibit, or prevent some proposal for water use or development (6).

Political constraints are born out of the interest of someone or some group to oppose an action being sponsored by others. These constraints may be imposed by the direct intervention of counteractivists in normal planning, approval, and implementation processes, or they may occur as a result of influencing elected officials who can then sway the outcome of a project. The goal of the counteractivists is to delay, change, or prevent some proposed action. In days gone by, the environmental embodiment of the counteractivist was the "little old lady in tennis shoes." This is no longer the case; the eccentric lone advocate has been replaced by a throng of Rotarian types. Environmentalists, conservationists, and preservationists, for example, have taken strong positions in recent years on various aspects of many water projects. These groups are no longer the weakly heard "voices in the wilderness." Today many of them are well organized, sophisticated, experienced in all aspects of lobbying, and knowledgeable in methods for gaining strong public support for their views. Where such groups elect to oppose an issue, the proponents can expect a time-consuming and difficult uphill fight.

Opposition to a particular project may be confined initially to a few individuals or small groups. As time goes on, however, many of these will seek support from other groups who, although they may have different interests, generally stand against the type of action being considered. This combination of opponents increases the strength of the opposition and gives it a more formidable political dimension. The strategies of those opposing water projects may range from mass appeals and protests to testimony before review and regulatory bodies, to lobbying of elected officials, and to court action (6). Generally several or all of these mechanisms will be used simultaneously. Political constraints have an air of unpredictability associated with them. This is because they are subject to frequent adjustment by their creators as conditions and/or levels of support change. They represent the interests of their designers, however, and they must be reckoned with by those proposing new water developments or changes in water use. It has been said that political opposition "can turn what are otherwise procedural matters into major obstacles" (6). Political deterrents reflect the points of view of important interest groups and as such may be the most difficult of all institutional constraints to deal with.

Those seeking to implement water projects or programs are well advised to assess carefully the political feasibility of their proposals. Unless political support appears to be a likelihood, efforts to modify proposed courses of action to achieve the needed backing will be more productive than attempts to overcome hard-to-deal-with political constraints. For a broader view of the political process, the reader is referred to references 1, 4, 6, 9, 19, 20, 21, 22, 23, 24, 25, and 26.

3-10 TECHNOLOGICAL PROBLEM SOLVING UNDER INSTITUTIONAL CONSTRAINTS

Only those technical solutions to problems that are politically feasible, socially acceptable, and legally permissible will have any chance of implementation, short of lifting some of the constraints. The scientist and engineer must be prepared to evaluate the array of institutional constraints and then proceed to develop alternatives that can function within these limits. To seek the "best" technical solution without regard for its acceptability is to invite delay, added cost, and even total failure. On the other hand, the technologist has an important role to play in providing explicit analyses of the impact of existing constraints on addressing the water issues of his or her region. If the benefits to society can be clearly shown to increase as the result of modifying laws, changing regulations, developing new organizations, and so on, then the prospects for eventual reform in these areas will be enhanced.

PROBLEMS

3-1. List the major water planning, development, and management organizations in your state. Briefly describe their roles.

3-2. Are the operations of the organizations listed in Problem 3-1 coordinated? If so, how is this done?

3-3. Do you believe your state agencies should be consolidated or partly consolidated to permit more efficient water management? Discuss.

3-4. Summarize your state's water rights laws. Do they permit easy transfer of water rights? Do they encourage waste?

3-5. What are the principal institutional problems in your state? Discuss.

3-6. Are there any regional organizations with water management authority in your state? Discuss the strong and weak points.

3-7. Describe the degree of coordination between water quality and water quantity management in your state.

3-8. What long-standing social customs in your state have the greatest impact on water allocation and use? Do you think these customs can be altered? If so, how?

3-9. Discuss the nature of water "politics" in your state.

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UNEASY FEDERALISM—STATE WATER LAWS AND NATIONAL WATER USES*

Frank J. Trelease**

In late 1979 the Associated Press disseminated the following news story:

> Cedar City, Utah. (AP) Governor Scott Matheson Monday threatened to withdraw his support of the MX missile if the military tries to assert federal water rights for the proposed project in Utah and Nevada.
>
> [Matheson was] addressing a U.S. House subcommittee hearing . . . .
>
> . . . Matheson told the subcommittee that he supports deployment of the missile in Utah, but he added that, "if at any point, the Air Force, because of difficulties or costs encountered, attempts to assert a federal water right for this project, I want them to know that I will withdraw my support for the MX project."
>
> He demanded an "ironclad commitment" from the Air Force that it would not assert federal water rights in order to acquire project water. Matheson said that the military must guarantee to secure water in accordance with state law.[1]

The proposed MX missile system will be a huge shell game, an intricate network of railway loops over which a limited number of missiles can be shuttled between thousands of launching pads or "shelters." If the Soviets should launch a strike aimed at knocking out America's capability for a counterstrike they will not know under which shell was the pea, and the sheer number of shelters would make it impossible for them to destroy all U.S. missiles. This $33 billion scheme has been called the world's largest construction project. Large amounts of water will be needed for building and maintaining it and for the workmen and military personnel who would construct and man the system, and there is not much water on the Utah desert.[2]

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* Walker-Ames Lecture, University of Washington, Seattle, Washington, April 10, 1980.

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[1] The Sacramento Bee, Nov. 6, 1979, § D, at 25, col. 1.

[2] To be more fair than the reporter, the news item reported approximately seven percent of the Governor's remarks, picked out of a thoughtful analysis of the social, economic, cultural, and environmental impacts of the MX, and the roles and responsibilities of the state and nation dealing with them. *Hearings on Proposed MX Missile Deployment Before the Subcomm. on Military Construction Appropriations of the House Comm. on Appropriations*, 96th Cong., 1st Sess. 37-49 (1979) (statement of Governor Scott M. Matheson of Utah).

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The Governor's objection was not to the United States getting the water, nor to the United States getting a water right,[3] but to the possibility that the United States would claim the water under its national defense powers rather than under Utah's water law. He said:

> As Governor of the State of Utah I need an ironclad commitment from the Air Force that they at no time will assert Federal water rights, reserved or unreserved. They must guarantee that all the water obtained by the Air Force will be secured through the process outlined in Utah State law.[4]

A complete understanding of this statement requires an examination of the uneasy coexistence of state and federal water laws.

I. WESTERN STATE WATER LAW

Western state water law grew out of the California gold rush, when thousands of '49ers crowded the diggings at the mouths of the Sierra canyons and staked their claims on the streambeds and banks. They made similar claims to the water needed to wash the gold from the gravel. Since there was neither gold nor water enough for everyone, both were put on a first-come-first-served basis. Claim jumping was discouraged by Colt and Winchester. When the Great American Desert was found to be habitable, the first settler in a valley took first choice of the land and took from the stream enough water to irrigate it; the second comer had to make do out of what was left.

The courts and legislatures of the western territories and states shaped this crude self-made law into the doctrine of prior appropriation.[5] An appropriation had to meet but one standard: it had to be for a beneficial use.

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[3] The Governor stated that the Utah State Engineer had reported that water in needed quantities was available. *Id.* at 45.

[4] *Id.* at 46. When the Governor threatened to "withdraw his support," he presumably meant his political support. I am sure he had something in mind milder than either "nullification" South Carolina style, or "interposition." *See* Goldberg, *Interposition—Wild West Water Style*, 17 STAN. L. REV. 1 (1964). He could not, of course, block the United States from establishing a military installation in the State of Utah, although something like this was once tried by a governor of Arizona, who in 1934 impressed the ferryboat *Julia B.* into the "Arizona Navy," and transported a detachment of the National Guard up the Colorado River to the Parker Dam site, to rout construction gangs working on a dam being built by the United States for the benefit of the City of Los Angeles. A second Fort Sumter was avoided by the United States' tactical withdrawal of the construction crews. The parties adjourned to the courtroom, where Arizona won a brief Pyrrhic victory, stopping the dam on a technical defect soon to be remedied by Congress. *See* United States v. Arizona, 295 U.S. 174 (1935). *See also* R. NADEAU, THE WATER SEEKERS (1974).

[5] McGowen, *The Development of Political Institutions on the Public Domain*, 11 WYO. L.J. 1, 8–14 (1956); Phillips, *The Doctrine of Appropriation: An Example of American-Born Common Law*, REPORT OF PROCEEDINGS, AMERICAN BAR ASSOCIATION SECTION OF REAL PROPERTY, PROBATE AND TRUST LAW 38 (1938).

Practically all of the farmers, miners, manufacturers, power companies, and cities of the West met this test when they took the water, since each had a practical wealth-producing use in mind. Each use advanced the development of the resources of the country, and was an increment toward maximization of the welfare of the people, the state, and the nation. Once begun, an appropriation became a definite and identifiable piece of property, lasting as long as the beneficial use continued. Its boundaries were marked by the quantity diverted from the source, the place the diversion was made, and its date, which identified it as superior or inferior to other appropriations. This property right could be sold, and the use or place of use could be changed, if the proper formalities were observed.

To help you understand this property aspect of water law, let me teach you as I learned it. Fresh out of law school, I became an associate of L. Ward Bannister of Denver, Colorado, one of the grand old "irrigation lawyers" of a past generation.[6] One day he called me to his office while he interviewed a farmer named Bergland, who had come into town with a water case. Bergland was obviously a hard worker; he had worn his Sunday suit in to see the big city lawyer and I noticed how his biceps filled his sleeves. Yet he was a very nervous and embarrassed man. The reason for this appeared as he told the story. He got his water from the Brighton Ditch Company, which served many farmers. One day he thought he had not received his full amount, and won the argument by beating up the ditch rider who doled out the shares. The ditch company promptly shut and locked the headgate to his lateral and would give him no more water. I thought this a funny story, but he did not, and I saw that he was not only embarrassed but that he was frightened, scared to death. Why, I wondered, did he perhaps fear jail? I heard him say "and if I don't get water in the next two or three days my corn will wither and my beets will harden." Then I understood: if he lost his crop he would lose a year's income, he would miss a payment on the mortgage, and he would lose his farm. On the high plains of northern Colorado, a farm is practically worthless without water. As I watched this big, strong, scared man, I learned what water law was all about. Water law ought to give to Bergland as good a water right as property law gives him a land right to his farm.[7]

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[6] Mr. Bannister represented the State of Colorado in the negotiations for the Colorado River Compact of 1922. He lectured in water law at Harvard Law School and the University of Denver College of Law.

[7] Mr. Bannister picked up the telephone, called his friend the attorney for the ditch company, told him some of the dreadful things that might happen to it, turned to Mr. Bergland and said, "You will have your water in the morning." He charged Mr. Bergland a dollar for the telephone call.

There is a second aspect of water law. Modern state water codes superimpose a layer of administrative law on this property law. Rights are no longer created solely at the will of the appropriator; now the state must concur. Today's appropriator applies for a permit to construct the works and to use the water, and a state official or agency decides whether there is unappropriated water for the use and whether the use is beneficial. The state officials determine the amount of water needed for the use and oversee the construction of the works. Most important, a new requirement has been added: the state agency may deny the application if to grant the permit would be "contrary to the public interest."[8] The agencies and courts have developed this into a very important policy which has enabled them to control water use with surprisingly modern and sophisticated economic concepts. The public interest now incorporates the economist's maximization or efficiency principle, requiring water officials to choose from competing projects the one that will produce the greatest net benefits.[9] Social costs have been recognized as grounds for denying or conditioning permits for projects that would have very bad external effects on others.[10] The Utah Supreme Court, for instance, employed the notion of opportunity costs in preventing a single-purpose appropriation from cutting the heart out of a great multi-purpose project.[11] In none of these cases did the judges use the economist's language, but they had no difficulty in recognizing and applying the economic concepts. In recent years legislatures have embroidered on these themes; the Alaska and Washington prior appropriation statutes contain express cost-benefit formulae[12] and several states identify specific recreational, fish, wildlife, and environmental values that must be considered or guarded in the water permit review process.[13] As a result, today the permit system forces appropriators to modify their projects to preserve environmental values.[14]

Water law is thus a planning tool, a guide to action, an aid to decision. A modern water plan is not a blueprint for every future project or use. If a proposed new water use is for a beneficial purpose, does not affect prior users, does not have deleterious side effects on other people, fish and game, recreation, and the environment, and if it does not foreclose better uses of the water, then it is a "planned" use, even though no one in government ever thought of it. Of course, a state water plan may reserve a stream for a specific project, or choose in advance to protect certain water from exploitation, and in this fashion the modern water planning process can be integrated with the permit procedure to provide policy guidelines that determine, in the name of the public interest, the disposition of the state's remaining unappropriated water.[15]

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[8] This legal device, now almost universal throughout the world, was invented by an engineer, Elwood Mead, then state engineer for the infant state of Wyoming. 1890 Wyo. Sess. Laws ch.8, § 34. Mead was later United States Commissioner of Reclamation, and his monument is Lake Mead, the water of the Colorado River stored behind Hoover Dam.

[9] Young & Norton v. Hinderlider, 15 N.M. 666, 110 P. 1045 (1910).

[10] *In re* Martha Lake Water Co. No. 1, 152 Wash. 53, 277 P. 382 (1929).

[11] Tanner v. Bacon, 103 Utah 494, 136 P.2d 957 (1943).

[12] ALASKA STAT. § 46.15.080 (1962); WASH. REV. CODE § 90.54.020(2) (1971).

[13] ALASKA STAT. § 46.15.080 (1962); CAL. WATER CODE § 1257 (West 1971); OR. REV. STAT. § 537.170(3)(a) (1979); UTAH CODE ANN. § 73-3-8 (1953).

[14] Bank of America Nat'l Trust & Sav. Ass'n v. State Water Resources Control Bd., 42 Cal. App. 3d 198, 116 Cal. Rptr. 770 (1974).

II. FEDERAL WATER LAW

The federal government has little water law that resembles this state water law. The national government does not concern itself with the property rights of water users; it does not regulate the conduct of citizens or plan what they may do with water. Federal water law deals primarily with the powers, projects, programs, and properties of the federal government; it governs the government. When the United States regulates the rivers with huge dams to control floods and improve navigation, it has no "water rights" as such.[16] When it deals with the problems of a great river basin it needs no state permit or approval.[17] Yet when it acts as a water supplier and builds projects that furnish water for irrigation, municipal and industrial purposes, it usually acts very much like a private appropriator that seeks to store water for beneficial use. Most of these projects have been built by the Bureau of Reclamation (now the Water Power and Resources Service) and section 8 of the Reclamation Act of 1902 requires the Secretary of the Interior, in carrying out a reclamation project, to proceed in conformity with the laws of the state "relating to the control, appropriation, use, or distribution of water. . . ."[18]

The federal government often has need to use water on its own land. Until a few years ago most agencies making such uses got state water rights, almost as if there were a universal section 8. The National Park Service got permits and adjudications for the needs of its tourists and personnel, the Forest Service for its campgrounds and small impoundments, and the Bureau of Land Management for its stock water ponds.[19] At least some military installations[20] and some Indian irrigation projects obtained state permits to take needed water.[21]

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[15] *See* WYO. STAT. §§ 41–2–107 to 110 (1977); United Plainsmen Ass'n v. North Dakota State Water Conservation Comm'n, 247 N.W.2d 457 (N.D. 1976).

[16] Oklahoma v. Guy F. Atkinson Co., 313 U.S. 508 (1941).

[17] Arizona v. California, 283 U.S. 423 (1931).

[18] 43 U.S.C. § 383 (1976).

[19] *See generally* 1 C. Wheatley & C. Corker, Study of the Development, Management and Use of Water Resources on the Public Lands (prepared for the Public Land Law Review Commission) 208-09, 238-40 (March 1969); *see also* United States v. New Mexico, 438 U.S. 696, 702–03 (1978).

Yet before the turn of the century the Supreme Court had made it quite clear that the states could not deny to the United States water needed for the beneficial use of government property.[22] Early in this century, when the federal government needed water for Indian reservations, it used this power to create its own "reserved rights" to irrigate the reserved lands set aside for the tribes.[23] Fairly recently federal officials have become aware that water was needed to carry out federal purposes on other types of reserved lands. Instream flows are desired for recreational uses or scenic and aesthetic purposes, and the federal agencies fear that state water rights, geared to utilitarian purposes and designed for diversion and development, would not be suitable for these federal purposes.

The new federal reserved rights are a species of water right owned by the federal government, created by the federal government to authorize and protect water uses by the federal government on and in connection with federal reserved lands. Their distinctive feature is that they bear a priority as of the date the reservation of land was set aside, not when the water use was started. Thus, an appropriator downstream from federal reserved land who finds water available and puts it to use pursuant to state law may not get the top prority although he is the first taker. Since they were invented in 1955[24] and first applied in 1963,[25] these rights frightened the Berglands, the mining companies, and the cities of the West, for many of them had water rights dating after the reservation of upstream federal lands. If the government were to take the water for use on the reserved land, it would have the better right, though not the first use, and the first user could lose his water.

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[20] Nevada *ex rel* Shamberger v. United States, 165 F. Supp. 600 (D. Nev. 1958), *aff'd on other grounds*, 279 F.2d 699 (9th Cir. 1960).

[21] *See* United States v. Ahtanum Irrigation Dist., 236 F.2d 321 (9th Cir. 1956); Merrill v. Bishop, 74 Wyo. 298, 287 P.2d 620 (1955).

[22] United States v. Rio Grande Dam & Irrigation Co., 174 U.S. 690 (1899).

[23] Winters v. United States, 207 U.S. 564 (1908). In 1874, a large part of Montana was set aside in the expectation that several tribes of the northern plains Indians could continue their way of life there. When the area proved too small and the buffalo disappeared, the Indians began to starve. In 1888 they were easily persuaded to gather in a smaller reservation on the Milk River where they could be given rations of beef, bacon, and flour. In order to help the Indians become self-sufficient farmers and ranchers, an irrigation project was started, but it was then found that there was insufficient water because upstream white settlers had appropriated the water to their lands. The Supreme Court came to the rescue of the Indians, saying that both the Indians and the United States had intended to reserve the water, the Indians to maintain command of the water that made their land valuable, the government to insure the purposes of civilizing the Indians. In my opinion this is pure fiction. I believe they simply forgot the water, or perhaps more accurately, did not think of it. An implied reservation of water, like many an implied term of a contract or interpretation of a statute, is an afterthought supplied by the court to fill a gap not seen by the original framers of the document. The court, armed with hindsight, supplies the provision it thinks the legislators or parties might have inserted if they had thought of it at the time.

Indian reserved rights present one of the knottiest problems in western water law. They are not the subject of this paper, and what is said here about federal non-Indian reserved water rights has very little to do with Indian reserved water rights.

[24] Federal Power Comm'n v. Oregon, 349 U.S. 435 (1955)(Pelton Dam case).

[25] Arizona v. California, 373 U.S. 546, 600–01 (1963).

Within the past year the federal government has come up with a claim to a new type of federal water right, what has come to be called the "federal non-reserved right." Much of the federal public domain is not reserved lands. Theoretically, much of it can still be privately acquired under a series of old land settlement and mining laws, although this is becoming increasingly difficult. The old policy of disposition of the public land to encourage settlement and development of the West has given way to a new policy of retention and management. In managing its unreserved public lands the government is discovering uses for water that it again fears will not be recognized by state laws. The new claim is that the national government can take or claim water for its national purposes without regard to whether the state recognizes that purpose as a beneficial use or whether the state laws will create and protect a right for it. The federal non-reserved water right would bear a priority as of the date of actual use or claim, so it does not threaten Mr. Bergland's vested rights. However, federal uses outside the state pattern of water rights could have a marked effect on the size and shape of future development within the states, so they do scare Governor Matheson.

The state water laws allocate water to users, the nation's laws proclaim it as a water user. The national government's reserved right presents a threat to the property-protection function of state water law, and its non-reserved rights threaten the development-guiding function. I think that Governor Matheson is, in a very different way, as frightened as Mr. Bergland. The direction and form of Utah's growth will depend to a large degree upon water—who gets it, how much, from which source, under what restraints, with what adjustments, and under what compromises. The Governor fears that the future of his state may be decided in Washington, rather than in Salt Lake City. He fears that decisions affecting the citizens of the state will be made not at the local or state level by the affected people or their legislators and agencies, but by national officers and administrators little informed or concerned about local matters.

While the states view the exercise of federal powers as a possible threat to the property rights they have established and to the development they prefer, the federal government sees state regulatory laws as potential state controls over federal functions. When Governor Matheson squares off in confrontation with the Air Force, he is reenacting an old role. State officials and federal agencies have long had a mutual distrust of the one's willingness or ability to fulfill the needs and desires of the other. Each jealously claims its own jurisdiction and prerogatives and resents the exercise of the other's. When federal reserved rights appeared on the scene, they not only scared the Berglands of the West but also frightened many lawyers and law professors and inspired briefs, articles, and speeches by the hundreds. I added to the heap one book, three chapters, two articles, four speeches, and two draft laws. When I noticed that there were no Berglands selling apples on the streets, no companies bankrupted by shutdown of their mills, no cities losing population and industry because their government had taken their water, I thought I could quit.[26] Yet each year brings a new development, and I find myself taking up the cudgel again. A new case seems to cut down reserved rights, but new claims expand them. I am not sure it is progress to move from concern over reserved rights to concern over non-reserved rights, but the latter threaten to spawn as big a controversy as the former once did.

III. FEDERAL RESERVED WATER RIGHTS

For twenty-five years the western states have engaged in a mighty struggle, first to disprove the existence of federal non-Indian reserved rights, then to secure their repeal. Both efforts have failed, and the Supreme Court has now squarely espoused the doctrine of reserved rights and has protected them as property rights of the government.[27] A whole generation of federal bureaucrats has been educated as to their existence and trained to enforce them to the hilt. Today, in numerous courts of the Western States, a massive effort is being made to identify and quantify these new-found rights and to weave them into the pattern of private rights that date from the earliest settlements to the present.[28]

Out of one of these state suits came the 1978 case of *United States v. New Mexico*.[29] At stake were the waters of the Rio Mimbres, a small stream that serves a surprisingly large number of ranches and communities before it sinks into the desert. The United States claimed that when the Gila National Forest was set aside in 1899, the government also set aside some of the water. The claims were modest enough: small amounts for residential use of Forest Service personnel and campers, for road building, a tiny bit for wildlife, and an instream flow of six cubic feet per second—a small brook—through the forest for "aesthetic, environmental, recreational and 'fish' purposes."[30] The Supreme Court gave the Forest Service enabling acts of 1891 and 1897 a strict reading.[31] Those acts had specified only watershed protection and timber supply in stating the purposes for which the national forests were created, and the Court allowed water only for these utilitarian objectives, not for the amenities claimed. The Court seemed generally unsympathetic to the entire notion of reserved rights. It emphasized that the quantities allowed would be limited to "only that amount of water necessary to fulfill the purpose of the reservation, no more";[32] it held that reserved rights exist not for "secondary" or "supplemental" purposes, but only for those that qualified as "direct."[33] "Necessary" was amplified to "essential"; the test applied was whether, if water were not provided, "the purposes of the reservation would be entirely defeated."[34]

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[26] Trelease, *Federal Reserved Water Rights Since PLLRC*, 54 Den. L.J. 473 (1977).

[27] Cappaert v. United States, 426 U.S. 128 (1976); Colorado River Water Cons. Dist. v. United States, 424 U.S. 800 (1976)(dictum).

[28] Appendix I to a preliminary report of the Task Force on Federal Non-Indian Reserved Water Rights lists 44 recently decided or pending cases in which federal non-Indian reserved water rights were adjudicated. Task Force 5a—President's Water Policy Implementation, Report of Federal Task Force on Non-Indian Reserved Rights, app. I (June, 1979) (review draft) [hereinafter cited as Task Force Report]. Many of these cases involved claims to all the tributaries in a river system in a large basin.

[29] 438 U.S. 696 (1978).

This was a substantial victory for the water users of the West.[35] The enemy was not defeated but he was thrown back, and substantial territory feared lost was recaptured. The decision confirmed, even strengthened, my belief that reserved rights were of little moment and not likely to harm many Berglands.

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[30] *Id.* at 704 (quoting Mimbres Valley Irrigation Co. v. Salopek, 90 N.M. 410, 412, 564 P.2d 615, 617 (1977)).

[31] 438 U.S. at 705–13. For example, the government argued, *id.* at 707 n. 14, that the Organic Administration Act of 1897, as codified in 16 U.S.C. § 476, should be read establishing three purposes for national forests, one general and two particular: "No national forest shall be established, [1] except to improve and protect the forest within the boundaries, or [2] for the purpose of securing favorable conditions of water flows, and [3] to furnish a continuous supply of timber . . . ." 16 U.S.C. § 475 (1976). The Supreme Court demonstrated that the legislative history showed that this should be read as intending only two purposes: "Forests would be created only 'to improve and protect the forest within the boundaries,' or, *in other words*, 'for the purpose of [1] securing favorable conditions of water flows, and [2] to furnish a continuous supply of timber.' " 438 U.S. at 707 n. 14 (emphasis in original).

[32] *Id.* at 700 (quoting Cappaert v. United States, 426 U.S. 128, 141 (1976).

[33] 438 U.S. at 702–03, 714.

[34] *Id.* at 700.

[35] This opinion is not necessarily infallible dogma, nor even received doctrine. In an excellent note, *Quantification of Water Rights Claimed Under the Implied Reservation Doctrine for National Forests*, 54 WASH. L. REV. 873 (1979), it is asserted that the decision does not provide adequate protection for the national forests and deprives the implied reservation doctrine of the flexibility which rendered it useful in balancing state and federal interests in water adjudications. With deference, I still believe that the national government can give its forests all the protection they need (*see* text accompanying notes 67–68 *infra*), although it may have to pay for appropriated water it needs and takes, and that the reservation doctrine is not a flexible balancing of interests but an owner-take-all enforcement of property rights. Cappaert v. United States, 426 U.S. 128 (1976).

United States v. New Mexico did not dampen the spirits nor reduce the efforts of the federal agencies. About that same time President Carter decided to announce a definite written water policy, which he described as an attempt to achieve "enhanced Federal-State cooperation" in water policy,[36] and to "deepen the partnership" between the two levels of government.[37] He instructed the federal agencies to "work promptly and expeditiously to inventory and quantify Federal reserved . . . rights,"[38] focusing on high priority areas and working in "consultation with the States and water users . . . emphasiz[ing] negotiations rather than litigation wherever possible."[39] Pursuant to directives that accompanied the policy statement, a task force of water using agencies was set up, and in June, 1979, it released a draft report for review.[40] The report recommends a unified approach by all federal agencies, each furnishing a description of the types of claims to reserved rights, an inventory of reservations, purposes and water sources, and an estimate of the cost of completely identifying and quantifying all water rights. It sets a timetable of five years for current consumptive uses of water, ten years for "actual" non-consumptive uses of water and reasonably foreseeable future consumptive and non-consumptive needs, extendable to fifteen years if management plans require.[41] The report's procedural recommendations add to court adjudications a process of "notification" of the right identified and quantified by agencies and the negotiation of agreements for incorporating these into state systems.[42]

The Task Force Report adds one possibly disturbing element to the federal reserved rights picture. It contains an assertion that there is a federal reserved right to sustain "a groundwater level for general ecosystem maintenance."[43] This right is identified only by stating that there is a complete lack of information about the groundwater necessary to maintain range land, forest, and fluvial systems or to prevent salt water intrusion in coastal areas such as national seashores or coastal wildlife refuges.

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[36] President's Remarks Announcing the Administration's Federal Water Policy, 1 PUB. PAPERS 1978 at 1043 (1979).

[37] *Id.* at 1043–44.

[38] President's Message to the Congress Transmitting Federal Water Policy Initiatives, 1 PUB. PAPERS 1978 at 1050 (1979).

[39] *Id.*

[40] TASK FORCE REPORT, *supra* note 28. Task Force 5a consisted of representatives from the Department of Interior, the Department of Agriculture, the Department of Defense, the Department of Energy, and the Department of Justice. The Task Force was chaired by one Associate Solicitor for Interior and coordinated by another, and representatives of the Department of Interior formed a majority of the staff of the task force. *Id.* at 3–4.

[41] *Id.* at 36–41.

[42] *Id.* at 43–49.

[43] *Id.* at 41.

If this means that groundwater levels must be maintained at or near the ground surface for subirrigation of large areas, it could result in locking up potentially valuable resources.[44] Perhaps swamps and marshes reserved as duck refuges or moose ranges must stay wet, but this grab at the total groundwater may far exceed the "necessary and essential" amount allowed in *New Mexico*. Coastal areas should be protected from salt water intrusion, of course, but in Alaska, Washington, and Oregon there are state groundwater laws that could handle the matter,[45] and in California, where it has been a serious problem, the federal government might well enter into the local institutional arrangements that are operating a successful program of recharge,[46] thus achieving the objective without sacrificing total use of the resource.

Simultaneously with the draft Task Force Report, the Solicitor of the Department of Interior issued an opinion to guide the National Park Service, the Fish and Wildlife Service, the Water Power and Resources Service, and the Bureau of Land Management in making their claims to water rights.[47] The reserved rights claimed by the Solicitor are fairly modest. There are no surprises in the claims he makes for reservations of water for national parks, monuments, recreation areas, and other areas administered by the National Park Service, nor for the preserves and refuges administered by the Fish and Wildlife Service. Indeed, following the "specific purpose" test formulated in the *New Mexico* case, the Solicitor finds that public recreation is not a specific purpose of the National Wildlife Refuge System; instead, it is a secondary purpose for which no water is reserved.[48] He also finds that Bureau of Land Management (BLM) lands designated as ranges "to protect and manage wild free-roaming horses and burros" are not reserved lands, though designated and maintained as sanctuaries,[49] so that the horses and burros will have to drink water obtained under state law.

The Solicitor's one broad claim of a reserved right relates to "public water holes and springs." In 1916 Congress authorized the President to reserve "[l]ands containing waterholes or other bodies of water needed or used by the public for watering purposes. . . ."[50] The legislative history shows that this law was needed "so that a person can not monopolize or control a large territory by locating as a homestead the only available water supply for stock in that vicinity."[51] Most reserved springs and water holes were withdrawn by an executive order in 1926.[52] For these the Solicitor abandons the restricted *New Mexico* approach. He states that the purposes for which the public water holes and springs were withdrawn "include stock watering and human consumption."[53] He goes on to add such other purposes as:

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[44] *See generally* Meyers, *Federal Groundwater Rights: A Note on* Cappaert v. United States, 13 Land & Water L. Rev. 377 (1978).

[45] Alaska Stat. §§ 46.15.010–.270 (1962); Or. Rev. Stat. §§ 537.505–.795 (1974); Wash. Rev. Code §§ 90.44.020–.250 (1979).

[46] *See* Governor's Office of Planning & Research, California Water Atlas 58 (W. Kahrl ed. 1979).

[47] Federal Water Rights of the National Park Service, Fish and Wildlife Service, Bureau of Reclamation and the Bureau of Land Management, 86 Interior Dec. 553 (1979) [hereinafter cited as *Opinion*]. This opinion was the first of the reports of individual agencies called for by the Task Force Report, intended to guide the agency in the application of the report and to be attached to appendices to the report.

[48] *Id.* at 607.

[49] *Id.* at 593–94.

> (1) water for growing crops and sustaining fish and wildlife to allow the settlers on the public land to obtain food for their families and provide forage for their livestock; and (2) water for flood, soil, fire and erosion control, the control of which was essential to protect the public and to allow the new patentees and settlers on the public domain to make a viable living in this arid and semi-arid region of the Nation where, for example, an uncontrolled prairie fire could completely destroy a home, life, belonging [*sic*], livestock and forage.[54]

"Springs and water holes" are held to include those tributary to streams.[55] Furthermore, the Solicitor opines that the quantity of water reserved at each public water hole or spring was the total yield of such source.[56] Out of this cloth he would create a new type of federally granted private water right, a system that rivals the state system of appropriation. Persons who have acquired nearby lands may receive permission from the Department of Interior to use these reserved waters beyond the area of land reserved.[57] This invention seems totally at war with the "primary purpose" doctrine of *New Mexico*, totally inconsistent with the rule that only so much water is reserved as is essential for the purpose.

The Solicitor says that any appropriation under state law of the water of a spring or water hole on federal land is a nullity, and that any entry on the land for that purpose is a trespass.[58] This will certainly create conflicts with those users of the public domain such as oil companies, mining claimants, and ranchers who have appropriated water which is surplus over stock water needs. Irrigators and other users of water downstream from tributary springs may find their water taken under the newly created "federal water rights law," if and when the federal government authorizes others to use its new-found water wealth—wealth never discovered, claimed, or used in the sixty-four years since the Stock Raising Homestead Act was enacted and the fifty-four years since the lands surrounding the water holes were reserved.

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[50] 43 U.S.C. § 300 (repealed 1976).

[51] H.R. REP. No. 35, 64th Cong., 1st Sess. 18 (1916).

[52] Public Water Reserve No. 107, Exec. Ord. of Apr. 17, 1926, 30 C.F.R. 758 n.1 (1979).

[53] *Opinion*, *supra* note 47, at 581.

[54] *Id*. at 581–82.

[55] *Id*. at 587.

[56] *Id*. at 582.

[57] *Id*.

[58] *Id*. at 588.

In another respect this portion of the Solicitor's opinion is in conflict with *United States v. New Mexico*. There too the Forest Service had claimed the power to allocate water to private users, in that case cattle ranchers, outside the structure of state water law, on the theory that the United States had reserved the water. The *New Mexico* Court analyzed several acts and administrative interpretations demonstrating turn-of-the-century thinking that the state had exclusive control of the distribution of water on public lands, and said, "there is no indication in the legislative histories of any of the forest Acts that Congress foresaw any need for the Forest Service to allocate water for stockwatering purposes, a task to which state law was well suited."[59] Exactly the same thing should be said of the Stock Raising Homestead Act and the executive order reserving the water holes.

IV. THE FEDERAL NON-RESERVED WATER RIGHT

The real bombshell in the Solicitor's opinion came in the assertion of "federal water rights obtained through appropriation and use for Congressionally authorized purposes"—federal rights to take unreserved but unappropriated water for use on unreserved federal lands, or for "secondary" uses on reserved lands, without complying with state law.[60]

The Solicitor first justifies such rights with variations on an old theme: the myth that the federal government owns the unappropriated water. I do not know why some lawyers and judges find it necessary to start with "ownership." I do not believe anyone owns the water in the ocean, in a cloud, in the raindrops, or in a stream. It is *res nullius*, the property of no one, a concept that has been with us since Roman times. If I catch it in a bucket, or behind a dam, perhaps it becomes mine, but if a state or nation can permit me to or prevent me from doing so, perhaps it can be called theirs. This "ownership," however, is obviously a conclusion, not a starting place.[61] But the Solicitor begins with "ownership of all rights appurtenant to" federal lands,[62] leans heavily on the rule that "only Congress . . . has the authority under the Property Clause to control the disposition and use of [property] owned by the United States,''[63] and ends where he began, with the opinion that the United States ''retains a proprietary interest in those waters that have not been appropriated pursuant to state law.''[64] He even embroiders on the myth, saying, quite erroneously, that the common law rules of natural flow riparian rights originally applied to federal lands.[65] Then, in a tortuous trip through cases dealing with the nineteenth century land laws, he finds, primarily from what they do not say, ''an assertion of inchoate federal water rights to unappropriated waters. . . .''[66]

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[59] United States v. New Mexico, 438 U.S. 696, 717 (1978).

[60] *Opinion, supra* note 47, at 574.

[61] Trelease, *Government Ownership and Trusteeship of Water*, 45 CALIF. L. REV. 638 (1957).

[62] *Opinion, supra* note 47, at 563.

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[63] *Id.* at 563, 575.

[64] *Id.* at 575.

[65] *Id.* at 565. The Solicitor cites United States v. Rio Grande Dam & Irrigation Co., 174 U.S. 690, 703 (1899), but the Court was there referring to state law and the lack of power of the states to change the common law to the detriment of the United States. In other cases the Court has said that riparian rights do not attach to federal lands. In Atchison v. Peterson, 87 U.S. 507, 512 (1875), the Court said: ''[T]he government being the sole proprietor of all the public lands, whether bordering on streams or otherwise, there was no occasion for the application of the common law doctrine of riparian proprietorship with respect to the waters of those streams.'' And in Sturr v. Beck, 133 U.S. 541, 551 (1890), the Court quoted this statement and added, ''when, however, the government ceases to be the sole proprietor, the right of the riparian owner attaches, and cannot be subsequently invaded.'' It is clear from the rest of the opinion that it attached in that case because of the Dakota Civil Code which stated the riparian doctrine, not because of federal law. *See also* Boquillas Land & Cattle Co. v. Curtis, 213 U.S. 339, 344 (1909).

[66] *Id.* at 565–66, 566–71. I used to think that one of the best and most useful works I had performed was to lay to rest the ghost of the myth that the United States ''owned the unappropriated water on the public domain'' because the Desert Land Act ''severed the water from the land'' and gave the states some power over water but reserved the surplus to itself. *See* F. Trelease, Federal State Regulations in Water Law (Legal Study No. 5, prepared for the National Water Commission) 111–116, 147–148 (including 147a through 147m), 306–309 (Sept. 7, 1971). Apparently, however, no one has ever read these pages, and the theory continues to haunt me. I must have seen it since in a half dozen law review articles. The Solicitor depends upon it heavily. A contemporary government report repeats it. GENERAL ACCOUNTING OFFICE, RESERVED WATER RIGHTS FOR FEDERAL AND INDIAN RESERVATIONS, CED–78–176 (1978). If Congress had clearly and unequivocally granted to the states the power to dispose of some of the waters, or granted to members of the public water rights obtained by complying with state law, then it would have impliedly acted on the theory that it owned all the water, and therefore retained an interest in what was left. But since there was no real grant, as I showed in Legal Study No. 5, to imply a grant and from the implied grant imply a claim to what was not granted seems one bridge too far. The Solicitor's opinion waffles through the Mining Act of 1866 and the Patents Act of 1870 (now combined as 43 U.S.C. § 661 (1976)), and concludes that since they ''in effect'' validated appropriations under state law and ''in effect'' waived U.S. claims to appropriated water, they therefore asserted ''inchoate rights to unappropriated waters that exist at any point in time.'' *Opinion*, *supra* note 47, at 565. The Desert Land Act he finds a puzzlement, and puzzling it is, if you try to read it as a federal water law, with its partial severence of some kinds of water from some kinds of federal lands in some states, instead of as a land law with a provision that the seller should get a state water right for as much as he needed, saving the surplus for others. Though he despairs of finding authority for his thesis in the inconsistent ''dicta . . . at war with one another'' in the cases construing these laws, he tenaciously clings to the United States' ''inherent power and control over its property'' and predicts that the Supreme Court will resolve the conflict by finding that nowhere in these acts, nor in the many disclaimers of intent to effect state water law, nor

When he moves from proprietorship to supremacy, he is on firmer ground. The Solicitor notes that the federal Constitution and laws are "the supreme law of the land," and quotes the National Water Commission: "Anytime the United States needs water . . . to carry out a program authorized by the Constitution, it has ample power to acquire it."[67] This of course comes from impeccable and irrefutable subordinate authority.[68] It is the theory I advanced to undercut the notion, quite prevalent a decade ago, that if the United States did not have reserved rights, the purposes of the reservations could be frustrated, state officials could deny water rights for purposes the national government had reserved the land for but which the state government did not regard as beneficial. I pointed out that under the Supremacy Clause this simply could not happen, and that the nation could acquire the water. I thought that if this myth were exposed, if the need to use the reserved rights doctrine was shown to be non-existent, Congress might be persuaded to eliminate the no-compensation feature of reserved rights so that if and when the United States took the water from Bergland's farm he would be paid the value that had been taken from him.

Now the Solicitor wants to keep the federal cake and eat it too. He wants federal reserved water rights for reservations, and federal non-reserved appropriations for non-reserved lands. The Solicitor thinks that the federal non-reserved right looks very much like a state water right, with a priority as of the date of actual use, and that there would be no conflict with state systems except in some situations in which a state would not recognize a federal use as beneficial or where instream flows needed for federal purposes were not recognized as an appropriation under state law.[69] He distinguishes substantive state water law and procedural state water law and says that when the United States makes such an appropria-

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in the few directives to federal agencies to use state water law, is there any general direction to comply with state law. *Id.* at 569–70. He ignores the fact that a year previously the Supreme Court had said that aside from reserved water the United States should acquire water in the same manner as any other appropriator. *See* note 72 *infra*.

[67] *Opinion*, *supra* note 47, at 575, *quoting* NATIONAL WATER COMMISSION, WATER POLICIES FOR THE FUTURE 466–67 (final report 1973).

[68] Trelease, *supra* note 66, at 147i–47l.

[69] *Opinion*, *supra* note 47, at 574-76. The Solicitor does not say why this should be so. It might be that if the United States merely seizes water in a manner inconsistent with state law, rather than taking over a state created right which can be measured by existing contours, or clearly establishing a right that would fit in with state right patterns, harm could be done to many other persons. *See* Trelease, *supra* note 66, at 227–30. We might be thrown back to the unhappy situation that existed in Dugan v. Rank, 372 U.S. 609 (1963), in which state water law was relegated to the sole function of determining the property rights for which compensation must be paid. *But see* California v. United States, 438 U.S. 645 (1978).

tion, the federal water right should be protected under state procedures as a matter of policy, though not as a legal requirement.[70]

He says this is the teeth of the Supreme Court's most recent pronouncement on the subject—Mr. Justice Rehnquist's statement in *United States v. New Mexico*, that when the United States has not reserved water, "there arises the . . . inference that Congress intended . . . , that the United States would acquire water in the same manner as any other public or private appropriator."[71] The Justice thus finds an "implied section 8" that requires the government to proceed in conformity with state law rather than to seize the water as an exercise of raw power.[72] The Solicitor labels this "dictum"[73] and prefers to rely on the statement in a prior case dealing with the reserved right: "Federal water rights are not dependent upon state law or state procedures. . . ."[74] This is surely a dictum when applied to non-reserved rights. Yet Justice Rehnquist's statement seems far more than mere dicta, in that it is aimed directly at the claimed water right that brought the *New Mexico* case to the Supreme Court. It could very well have been a deliberate attempt by the Justice to settle this phase of federal-state controversy. He says that a careful examination of the purposes for reserved rights is required "because of the history of congressional intent in the field of federal-state jurisdiction with respect to allocation of water."[75] He continues: "Where water is necessary to fulfill the very purposes for which a federal reservation was created, it is reasonable to conclude, even in the face of Congress' express deference to state water law in other areas, that the United States intended to reserve the necessary water."[76] But then, if that intent cannot be found, "there arises the contrary inference. . . . "[77] He notes that Congress has appropriated funds for the acquisition under state law of water to be used on federal reservations. He notes that the agencies responsible for administering the federal reservations have recognized Congress' intent to acquire under state law any water not essential to the specific purpose of the reservation. He rendered this opinion on the same day that he delivered the opinion in *California v. United States*, which held that under the Reclamation Act of 1902 a state may impose any condition on the control, appropriation, use, or distribution of water in a federal reclamation project which is not inconsistent with clear Congressional directives respecting the project.[78]

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[70] *Opinion*, *supra* note 47, at 577.
[71] United States v. New Mexico, 438 U.S. 696, 702 (1978).
[72] *Id.* at 701–03. *See* note 18 and accompanying text *supra*.
[73] *Opinion*, *supra* note 47, at 576.
[74] *Id.*, quoting Cappaert v. United States, 426 U.S. 128, 145 (1976).
[75] United States v. New Mexico, 438 U.S. 696, 701–02 (1978).
[76] *Id.* at 702.
[77] *Id.*

All this is brushed aside as dicta, given no weight or credence, on the basis that it is inconsistent with federal supremacy. The Solicitor does not recognize that Mr. Justice Rehnquist is saying that Congress has exercised its supreme powers by impliedly acceding to state law for the establishment of instream flows. He is too intent on finding a "congressionally authorized program" on which to base federal appropriations of such flows. He finds authority to claim them for the BLM in section 102 of the 1976 Federal Land Policy and Management Act:

> (a) The Congress declares that it is the policy of the United States that—
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> . . . .
>
> (2) the national interest will be best realized if the public lands and their resources are periodically and systematically inventoried and their present and future use is projected through a land use planning process coordinated with other Federal and State planning efforts;
>
> . . . .
>
> (8) the public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values; that, where appropriate, will preserve and protect certain public lands in their natural condition; that will provide food and habitat for fish and wildlife and domestic animals; and that will provide for outdoor recreation and human occupancy and use.[79]

On March 5, 1980, the United States filed in a Wyoming court a Statement of Claims that asserts the first "federal non-reserved rights." The suit is one brought to settle all water rights to the Big Horn River and its tributaries, all waters in a basin that covers one-fifth of the state.[80] Over half the land is national forest or federal grazing land, but on the private lands are cities, towns, ranches, irrigated farms, oil fields, coal mines, and uranium mines—a prosperous and growing economy. The document consists of seventeen pages of computer printout, listing on each line a claimed appropriation of what seems to be the base flow of every creek and rivulet in the basin that touches BLM land. The claimed priority date is October 21, 1976, the date of the Federal Land Policy and Management Act. The purpose claimed is to preserve and enhance the fisheries and wildlife habitat on the federal land. After a preliminary survey, the State Engineer of Wyoming said if these claims are sustained there will be no water for any new appropriations for any private purpose.[81]

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[78] California v. United States, 438 U.S. 645 (1978).

[79] 43 U.S.C. § 1701 (1976).

[80] *In re* General Adjudication of All Water Rights to Use Water in the Big Horn River System and Other Sources, Civ. No. 4993 (Dist. Ct. Wyo., filed Mar. 5, 1980).

It seems doubtful that these claims can rest on the quoted section of the Act. That section does not, on its face, authorize anything; it is a declaration of policy. To implement the policy the federal lands must be inventoried and identified,[82] and the Secretary of Interior must then develop plans which can be implemented with "management decisions" after public involvement and coordination with state and local plans.[83] The plans will then control sales, withdrawals, acquisitions, exchanges, and conveyances of the lands, and reservation and conveyance of minerals.[84] None of this has been done. Even if it were there is nothing in the Act to authorize the appropriation of water. There is no section comparable to the express authority given to the Secretary of Agriculture to appropriate water for the national forests.[85] There is not a word about water in the sixty-three pages of legislative history, nothing to indicate that Congress intended such sweeping powers with such drastic effects. Most important, another section of the Act seems directly to forbid the exercise of such power. Section 701(g)[86] provides:

> (g) Nothing in this Act shall be construed as limiting or restricting the power and authority of the United States or
> (1) as affecting in any way any law governing appropriation or use of, or Federal right to, water on public lands;
> (2) as expanding or diminishing Federal or State jurisdiction, responsibility, interests, or rights in water resources development or control;
> . . . .

Yet the federal government's Statement of Claims[87] asserts that on the day the Act was passed, by virtue of the Act itself, all these instream appropriations sprang into life. Is not the United States claiming that a federal right to water on public lands has been affected, that federal interests or rights have been expanded, and that state jurisdiction has been diminished?

A similar exception might be taken to the Solicitor's claims to nonreserved rights for public accommodations and recreation on the lands administered by the Fish and Wildlife Service. Claims of federal rights for the National Wildlife Refuge System seem out of line, since the Organic Act for that system provides: "Nothing in this act shall constitute an express or implied claim or denial on the part of the Federal Government as to exemption from State water laws."[88] Is not the United States expressly claiming exemption from state water law?

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[81] Telephone conversation with George Christopolus, State Engineer of Wyoming (Mar. 27, 1980).

[82] 43 U.S.C. § 1711 (1976).

[83] 43 U.S.C. § 1712 (1976).

[84] 43 U.S.C. §§ 1713–1716, 1718 (1976).

[85] Department of Agriculture Organic Act of 1944 § 213, 16 U.S.C. § 526 (1976).

[86] 43 U.S.C. § 1701 note (1976).

[87] *See* notes 80–81 and accompanying text *supra*.

V. THE FUTURE FOR RESERVED AND NON-RESERVED RIGHTS

In the quarter of a century since the United States Supreme Court discovered the federal non-Indian reserved right, a great deal of energy has been devoted to the effort to eliminate this "sword of Damocles" hanging over western water rights.[89] Perhaps not all that effort was tilting at windmills, but the fact remains that we have yet to discover a single case of harm to the holder of a state-created water right resulting from the exercise of a federal reserved right. One of the new developments that prompted this paper confirms the belief that the federal non-Indian reserved right is *de minimis*; the case of *United States v. New Mexico* severely restricts its size to the minimum quantity essential to maintain the reservation.[90]

The two recent claims to new types of reserved rights do not seem to add much of a threat. Quite probably no harm will result from the new reserved right to groundwater for ecosystem maintenance (subirrigation?) discovered by Task Force 5a[91] or from the expanded water hole reservation asserted by the Solicitor.[92] As for the former, only in a very few parks, monuments, and wildlife refuges would maintenance of surface vegetation be so essential that the purpose of the reservation would fail unless it were maintained. As for the waterholes, an unpleasant surprise might be in store for post-1926 appropriators who take from these small sources the surplus over stock water needs when they are challenged as trespassers,[93] yet the likelihood seems small that the courts will uphold the Solicitor's extravagant claims. The claim of the total available supply seems inconsistent with the *New Mexico* stricture and it is hardly believable that in 1910 Congress set up a system of federal private water rights that supersedes the state system of appropriation in this tiny area.

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[88] 16 U.S.C. § 668(dd)(i) (1976).

[89] Statement of Northcutt Ely, on behalf of the American Bar Association, before the National Water Commission (Nov. 6, 1969).

[90] *See* notes 29–34, 71–72 and accompanying text *supra*.

[91] *See* notes 43–46 and accompanying text *supra*.

[92] *See* notes 50–58 and accompanying text *supra*.

[93] *See* note 58 and accompanying text *supra*.

A similar question must be raised as to the practical importance of the federal non-reserved water right. Will it be used by the government to justify large federal projects? I think the answer is yes, in the sense that the government will exercise national powers when it undertakes new basin-wide or interstate projects or uses water incidental to flood control and navigation improvements, as it has in the past.[94] I think the answer is no, if they are reclamation projects subject to the section 8 conformity requirement, unless Congress gives a clear directive inconsistent with the application of state law.[95] Will federal non-reserved rights be used to provide water for giant new steam power facilities, coal slurry pipelines, coal gasification plants, and synthetic fuel plants constructed and operated by the coal, electric, and energy industries but authorized and licensed by federal legislation? The answer is no, if present readings of the mood of Congress are accurate. Alert western congressmen have inserted into pending bills for coal slurry pipelines and priority energy projects ("fast track" legislation) provisions that require the United States or its permitees or licensees to acquire water rights by complying with state laws.[96] President Carter has stated his concurrence with these provisions.[97] Will federal non-reserved water rights be used to supply water for the construction and operation of the MX missile system? Possibly. An Undersecretary of the Air Force stated to a congressional committee that the Air Force would prefer to comply with state water laws; but the White House has not yet worked out a firm administrative position on this sensitive issue.[98] No, said the Congressman from Nevada, legislation authorizing the system will include the similar amendments to protect western interests, including explicit congressional recognition of state rights in water allocation.[99]

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[94] *See* notes 16–18 and accompanying text *supra*.

[95] 43 U.S.C. § 383 (1976); California v. United States, 438 U.S. 645 (1978). *See* text accompanying note 78 *supra*.

[96] *See* H.R. 4370, 96th Cong., 1st Sess. (1979), *accompanied by* H.R. REP. NO. 692 Part I, 96th Cong., 1st Sess. (1979), *and discussed in* 125 CONG. REC. H10016–18 (daily ed. Oct. 31, 1979); H.R. 2610, 96th Cong., 1st Sess. (1979); S. 1308, 96th Cong., 1st Sess. (1979), *discussed in* 125 CONG. REC. S13925–27 (daily ed. Oct. 3, 1979).

[97] On October 10, 1979, at a "working dinner" attended by the President and six Western Senators, the President stated:

> I have and will continue to support legislative language to make it clear that federally-supported energy development should be accomplished without preemption or change of state water laws, rights or responsibilities. . . . We must respect the rights and responsibilities of our state governments—and when the issue is priority of water use in a state, the state must and does have the ability to say "no" through existing state water allocation systems.

WESTERN WATER NEWS, Oct. 12, 1979, at 2.

[98] The Sacramento Bee, Jan. 28, 1980 (AP dispatch).

[99] *Id.*

VI. INSTREAM FLOWS

What is left, of any importance? The entire effort of the Task Force and the Solicitor seems devoted to the establishment of instream flows on the public lands administered by the Bureau of Land Management. Throughout the Task Force Report the instream flow is identified over and over again as the area of federal need most likely to suffer from state laws that do not recognize the type of water right needed for federal programs.[100] The Solicitor's major claim is to instream flows to meet the "management objectives" of the 1976 Federal Land Policy and Management Act.[101]

One might think from this federal sense of urgency that as a whole the western states were inimical to instream flows. It is true that the West has had a long struggle making the transition from pure utilitarianism to recognition of these amenities. The history of this movement and the rich variety of state authority available for the purpose are well documented.[102] The precedents go back over half a century, when the Oregon legislature took the first step in 1915 and withdrew from appropriation the streams forming the beautiful waterfalls along the Columbia River gorge.[103] That state has since withdrawn many waters famous for steelhead and salmon fishing. Idaho uses a similar technique; the legislature has authorized the Governor or the State Park Board to appropriate specific beautiful lakes and streams in trust for the public.[104] In Colorado the State Water Conservation Board can appropriate minimum flows "to preserve the natural environment to a reasonable degree,"[105] while in Montana, the state, any political subdivision or agency, *or the United States* may apply to the Board of Natural Resources for a reservation of water to maintain a minimum flow.[106] In California and Oregon, wild rivers and free flowing rivers have been legislatively established.[107] In California attempts by the state fish and game officials and a sportsmen's organization to appropriate instream water for fishing have been blocked by the courts for lack of diversion,[108] but the Water Resources Control Board is studying regulations that could limit or prohibit further diversion permits on certain streams.[109] In Washington, one instream appropriation by a private person has been allowed,[110] and minimum flows can be set by administrative agencies.[111] In California and Alaska every permit application is reviewed by fish and game officials.[112]

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[100] TASK FORCE REPORT, *supra* note 28, at 13–16, 39, 44, 48, 73–74.

[101] *Opinion*, *supra* note 47, at 615. *See* notes 79–86 and accompanying text *supra*.

[102] Tarlock, *Appropriation for Instream Flow Maintenance: A Progress Report on "New" Public Western Water Rights*, 1978 UTAH L. REV. 211; R. Dewsnup & D. Jensen, State Laws and Instream Flows, (prepared for United States Department of Interior, Fish and Wildlife Service, Mar. 1977); Tarlock, *Recent Developments in the Recognition of Instream Uses in Western Water Law*, 1975 UTAH L. REV. 871.

[103] OR. REV. STAT. § 538.200 (1979).

[104] IDAHO CODE §§ 67–4301 to –4304 (1973).

[105] COLO. REV. STAT. § 37–92–102 (1973).

[106] MONT. REV. CODES ANN. § 85–2–316 (1979).

[107] CAL. PUB. RES. CODE § 5093.50 to –.69 (West Supp. 1980); OR. REV. STAT. § 390.805 (1979).

Not every state has such laws. In some Rocky Mountain States, where the streams are fully or over appropriated and there is little activity in the granting of new permits, no action has been taken. In both Wyoming and Alaska bills to establish procedures for obtaining minimum flows have been rejected by the legislatures, but even this represents a conscious choice by the policy-making body of the state. One reason for lack of interest in the Wyoming legislation was that early downstream priorities guarantee upstream instream flows; prior rights on the prairies insure that water will flow in the mountain canyons.[113] And in all of these states the water officials can protect an instream flow by denying or conditioning a permit in the name of the public interest.[114]

These decisions and processes are planning tools, the devices used by states to control and manage their future. A state may plan for economic growth and development, and it may plan for outdoor enjoyment and recreation. It can do both, since prosperity and progress demand recreation and a pleasing environment. Some uses of water are private and create wealth, while others are public and produce other satisfactions. The proprietary uses are usually for irrigation, municipal, manufacturing, food processing, and power production purposes, although resorts may cater to vacationers and sportsmen. The public uses are primarily for recreation, scenic, boating, fishing, swimming, hiking, fish propagation, wildlife habitat, and environmental and ecological values. Instream flows mean homes for trout and salmon, a delight to the eye, sport for the fisherman. They may also mean locked-up streams—no water for increased irrigation and food production, for industry, jobs, or city growth. The question is, who decides the mix?

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[108] Fullerton v. State Water Resources Control Bd., 90 Cal. App. 3d 590, 153 Cal. Rptr. 518 (1979); California Trout, Inc. v. State Water Resources Control Bd., 90 Cal. App. 3d 816, 153 Cal. Rptr. 672 (1969).

[109] The Sacramento Bee, Feb. 17, 1980.

[110] Bevan v. State Department of Ecology, PCHB No. 48 (1972).

[111] *E.g.*, Wash. Rev. Code § 90.22.010 (1979).

[112] Alaska Stat. § 46.15.080 (1977); Cal. Water Code § 1257 (West 1971).

[113] F. Trelease, III, Hydrology and Water Law (Water Law and Management Seminar, Instream Flow Group, Ft. Collins, Colorado, Sept. 1979).

[114] Alaska Stat. § 46.15.080 (1977); Ariz. Rev. Stat. Ann. § 45–143 (Supp. 1979–1980); Nev. Rev. Stat. § 533.370 (1979); Wyo. Stat. § 41–4–503 (1977).

All of the devices for reserving streams, establishing free flowing rivers, controlling appropriations, appropriating instream flows, setting minimum flows—and even the lack of any of these—are choices made by legislatures, officials, and agencies of the states. In each state these decisions, processes, and results represent a balance between public and private interests, between the wealth-producing and the amenity-preserving pressures faced by local politicians.

What Governor Matheson and state water administrators all over the West fear is that in the future these balances will not be tested. The sole question may be: "Will this piece of federal land be benefitted by maintaining a flowing stream?" In large areas of the West there will be no opportunity to balance interests, compare uses, choose between uses, or choose alternative uses. The development of a particular state could be controlled not by what state legislators, officials, and agencies feel is good for the state, but by what federal regional officials think is good for the public land within the state. Where the state has struck a balance it may be upset. If no provision has been made for instream flows because of a desire to use the water for the future growth of cities, food production, or energy production, the waters will nevertheless be withdrawn. Where the state has struck its balance in favor of some instream uses with its program of wild rivers, state-selected recreation sites, and state-set minimum flows, it may find that balance upset by a large federal program added on top of the state program, going far beyond the line the state authorities have drawn.

VII. CONCLUSION

The Task Force and the Solicitor argue that if the federal agencies must follow state law, the application of federal law will not be uniform throughout the states, and the effect of federal programs will differ from state to state. This is anathema to the Task Force. Its report asserts a "national interest in management of federal lands which cannot be limited by state lines."[115] The report points out that Congress has designated purposes as diverse as protecting fish and wildlife habitat, safeguarding lands through watershed protection, producing food and fiber for the nation's needs, meeting national energy goals, providing for the national demand for outdoor recreation, and preserving ecosystems in their natural condition.[116] Yet even if these are national purposes, quite obviously there cannot be national uniformity in their implementation. The same measures would not be taken in Arizona as in Alaska. We are back to the same question: "Since there will inevitably be differences, who will decide the proper local use of water?"

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[115] TASK FORCE REPORT, *supra* note 28, at 13.

[116] *Id.*

At least for the Forest Service these differences are to be resolved according to the different state laws. The Supreme Court said in *United States v. New Mexico*[117] that, in establishing the national forests, Congress intended that for certain purposes the Forest Service should have reserved rights, but for other purposes it must look to state law. Congress' intention was to allow instream flows in the forests to the extent that state law allows them. Although the Solicitor thinks Mr. Justice Rehnquist's statement was dictum, he said very clearly that when the Forest Service wants an instream flow, Congress intended that the United States would acquire the water right in the same manner as any other public or private appropriator—according to state law.[118] This appears to be a deliberate choice between nationwide uniformity and intrastate conformity.

In *California v. United States*,[119] the Court emphasizes the physical and climatic differences between the western states as justifications for section 8 of the Reclamation Act, which mandates that state law shall govern reclamation projects for the production of food and fiber. Why should not the same be true of instream flows? Considering that Mr. Justice Rehnquist handed down *California v. United States*, and *United States v. New Mexico* on the same day, and that in *New Mexico* he cited *California*, it seems reasonable to believe that his justification for state-to-state variation of federal reclamation projects carried over to justify his quite specific ruling that national forests' claims to instream flows should be governed by state law. Is there any reason to believe that the Court will not apply this same treatment to BLM lands? Since the Solicitor does not admit the possibility, he gives no argument against it. Since my sympathies are obviously elsewhere, I find it difficult to think of any.

I think it very likely that the federal non-reserved right to appropriate instream flows on the public domain without regard to state law will have a short life. But if I am wrong on the law of federalism and the Solicitor's arguments carry the day in court, other voices might carry the day in Congress. If federal uniformity means that claims such as those filed in the Big Horn Basin of Wyoming[120] will blanket the western public lands, Governor Matheson will surely raise his voice, and he will be leader of a chorus. Although a generation of "Barrett bills" to abolish reserved rights failed in Congress,[121] a bill to restrict non-reserved rights might well fare better. Congress is alert to the problem, as the slurry pipeline and energy mobilization bills demonstrate.[122] We in the West no longer fear that "the Feds" will take Bergland's water from him and set him to selling apples in the street. But we know that the federal government has the power to override state laws, because we have seen it in air and water pollution control.[123] If Congress decides this country needs the MX missile and authorizes its construction in Utah, Governor Matheson and the Utah State Engineer know that they could not (and of course they would not try to) block it by denying the water to the federal government because they wanted the water to be used for other purposes. The national security has supremacy over the interests of a single state.

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[117] 438 U.S. 696, 702 (1978).

[118] *See* notes 72–78 and accompanying text *supra*.

[119] 438 U.S. 645, 649 (1978).

[120] *See* note 80 and accompanying text *supra*.

But if there is real ground for Governor Matheson and the rest of us to fear that "the Feds" will take our future from us and override our plans and our decisions in the name of single-purpose management of the federal lands, I believe Congress would be willing to say that federal supremacy over desert and tundra, barren mountain and sagebrush grassland, does not require federal domination of water to the exclusion of state desires for multiple-purpose development. The time may well be ripe for the enactment of a universal "section 8" calling for conformity to state law whenever the government, as a land manager, is in competition with other land and property managers.[124]

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[121] Morreale, *Federal-State Conflicts Over Western Waters—A Decade of Attempted "Clarifying Legislation,"* 20 RUTGERS L. REV. 423, 423 (1966).

[122] *See* note 96 *supra*.

[123] 33 U.S.C. §§ 1251–1376 (1976); 42 U.S.C. §§ 7401–7642 (II Supp. 1978).

[124] A commendable new approach to such legislation is being drafted by Charles B. Roe, Jr., Senior Assistant Attorney General for the State of Washington, and Wilbur Hallauer, Director, State of Washington Department of Ecology. The unpublished draft bill in part calls for (1) quantification of all reserved rights, (2) termination of unexercised non-Indian reserved rights, (3) a federal water project fund to provide water to Indian reservations. Both the National Association of Attorneys General and the Conference of Western Attorneys General have endorsed the concepts of the bill in principle.

INSTITUTIONAL BARRIERS TO NATIONAL WATER POLICY

by David C. Harrison

Institutional barriers to integrated water resource *management* are generally well documented. They include: artificially low water prices which discourage conservation and create shortages; legal obstacles to the transfer of surface water rights in California and other western states from low-value cash crops to high-value crops or other beneficial uses; lack of coordination between the Federal government and the states and between the states and local governments, which prevents integrated ground and surface water management; a water policy conflict between the previous administration and the Congress, which contributed to further delays in Federal water project authorizations (project implementation already averages 26 years for Federal flood control proj-

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DELAWARE RIVER BASIN COMMISSION
UNITED STATES OF AMERICA
NEW YORK
NEW JERSEY
PENNSYLVANIA · DELAWARE
WRC
NA WC
NATIONAL WILDLIFE FEDERATION
WESTERN STATES WATER COUNCIL
SWC
INTERSTATE COMMISSION ON THE POTOMAC RIVER BASIN
ESTABLISHED BY ACT OF CONGRESS 1940
NACD
U.S. DEPARTMENT OF THE INTERIOR

Reproduced from Harrison, David C. Institutional barriers to national water policy. Water spectrum, v. 14, spring 1982: 1-7.

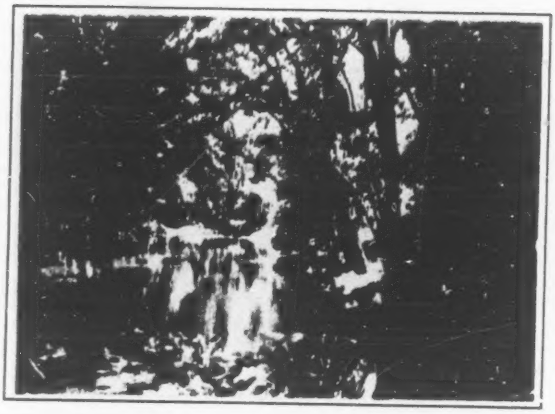
ects); lack of coordination among Federal programs and between Federal and state programs, which prevents integrated water quantity and water quality management; inconsistent Federal cost sharing arrangements for water projects; and overlapping or conflicting agency missions, laws, and programs, and fragmented Congressional committee responsibilities. *(See "Planning Versus Implementation: The Story of the Seventies," in* Water Spectrum, *Vol. 14, No. 1, Winter 1981-82.)*

Institutional barriers to national water *policy* are less well understood. A review of the progress and problems experienced by the institutional structure established by the Water Resources Planning Act of 1965 will show that the act strengthened intergovernmental roles and relationships, primarily between the state and Federal levels. It authorized Federal interagency and Federal-interstate policy making and coordinating mechanisms. It also provided Federal financial support for statewide comprehensive planning and coordination, thus materially strengthening many states' water management capabilities.

Implementation of the act revealed the presence of continuing institutional barriers to water policy both on a national and on a regional scale. These eventually led to the abandonment of the institutional structure created by the act. At the Federal level, the Water Resources Council provided a useful mechanism for interagency coordination and communication. It was unable, however, to address major water policy conflicts or, when it attempted to do so, to commit its members to collective policy decisions. The council tended to function outside the main cabinet structure and lacked accountability. It similarly operated without strong ties to non-Federal interests and thus possessed neither accountability nor a strong constituency within the Federal executive branch or outside of it. Its role in Federal water project decisions was perceived to be negligible until it produced project planning guidelines and was directed to perform an independent project review function on the basis of its guidelines, and then it was perceived to be obstructive.

Comprehensive management plans for interstate river basins provided useful sources of information and resolved major water policy conflicts while participating states and Federal agencies were committed to the planning process. But they did not commit the intergovernmental structure to collective policy or to plan implementation, as they were intended, or to the performance of a continuing policy guidance function. A participating agency, for example, might approve the adoption of a river basin plan by a river basin commission and subsequently recommend management measures for local or Congressional approval that would comply with its legislative mandate but conflict with the river basin plan. Or the planning process would omit certain issues or considerations, such as minimum flow requirements for power generation and other uses, because an agency or utility did not participate or because its interests are fixed by law and therefore not subject to change through a flexible policy guidance process. Where serious interstate conflicts arose, for example, over proposed inter-basin water diversions, member states might choose to maintain a policy vacuum in anticipation that the issue would reach the Supreme Court rather than refer it to planning machinery that could not reach binding agreements.

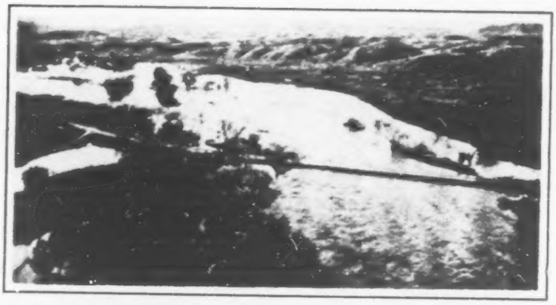
The urgency of dealing with water resource problems today comes from their increasing severity and the perception that institutional barriers, perhaps more than technology, prevent solutions. It also comes from the change in administrations and economic conditions which open up the opportunity to make fundamental changes in institutional and intergovernmental roles and relationships. Both the need and the opportunity are present to strengthen the role of non-Federal interests—the states, local governments, and private sector—in national water policy. For the management of the nation's water resources is primarily a non-Federal responsibility. A fundamental issue is whether this can be done flexibly, in ways that will recognize and preserve regional differences.

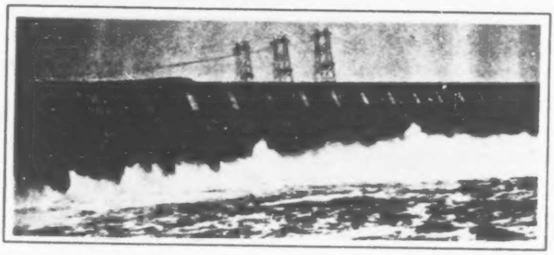


ABOVE: The urgency of dealing with water resource problems today comes from their increasing severity and the perception that institutional barriers, perhaps more than technology, prevent solutions. (Corps of Engineers photos.)

TOP RIGHT: Implementation averages 26 years for Federal flood control projects.

BOTTOM RIGHT: The planning process would omit certain issues or considerations, such as minimum flow requirements for power generation and other uses, because an agency or utility did not participate or because its interests are fixed by law and therefore not subject to change through a flexible policy guidance process.





WATER POLICY PROCESS

Policy describes rules or guiding principles that evolve from the resolution of conflicts between competing values or needs. For example, the conflict between the need to prevent loss of life and property damage from flood hazards in downstream communities, and the need to prevent environmental and social disruption from dam construction in upstream communities, might be resolved by a policy that generally rejects dams in favor of local protection works or nonstructural measures such as improved flood warning and community preparedness, or selective relocation and floodproofing over time.

A policy that is relied upon to guide decisions in any one situation represents a choice among competing economic, environmental, and social considerations to determine the outcome for these circumstances. For example, resource conflicts between navigation and commercial fishing interests where the location of a navigation channel may destroy part of an oyster bed create the need for guidance and at the same time create the considerations—competing social values that airse from beneficial and adverse impacts—that will provide guidance. The application of these values to resolve issues as they occur, through the selection of controlling values or "policies" for each issue, describes the overall policy guidance process. National economic development today will usually be the controlling consideration in policy conflicts, viewed from a national perspective.

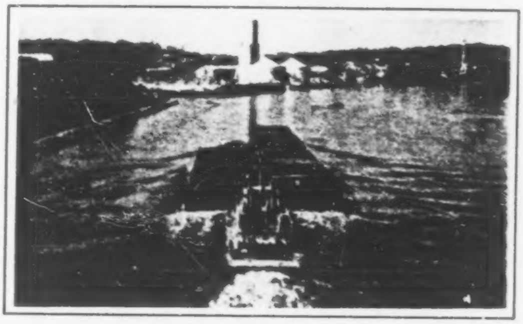
A government that provides adequately for the development and application of policy guidance can anticipate and plan for future water supply, flood management, or other crises. It can then apply the considerable administrative and other costs of dealing with crises toward the realization of economic or other needs. Additional economies are achieved through the resolution of resource management conflicts at appropriate levels of government, starting with the lowest possible level, and through coordinated management of regional surface and groundwater systems.

POLICY GUIDANCE FOR WATER RESOURCES SYSTEMS

The process begins with recognition that water resource systems—rivers and their interconnected tributary systems, groundwater aquifers, and related lands—are better managed as systems. Moreover, public needs associated with these systems are best served collectively, because water resource systems are shared resources and cannot meet the needs of one interest, or constituency, without affecting the needs of others. The process "integrates" water management by identifying, for every conflict between competing needs or values, a controlling consideration—some economic, environmental, or social value—that represents the highest public good for those circumstances.

The means generally do not exist for identifying public values and for applying them to resolve water policy conflicts within a watershed context on a sustained basis. This causes disatisfaction with the water policy process as a whole and specifically with procedures for planning and authorizing water development projects. Time, expense, and effort invested in the development and frequent revision of management planning procedures are substantially wasted because these procedures do not occur within the overall context of a policy guidance process.

Existing procedures and institutions for developing water projects place various obstacles in the path of determining appropriate controlling considerations or policies in the broad public interest. The nation's water policy structure has generally evolved piecemeal from specific needs, such as irrigation for agriculture and flood damage reduction, and governmental responses. it is an accumulation of things grafted onto one another rather than a structure designed and built rationally from the ground up, and therefore may lack an internal logic that is relevant to today's needs. The flow of institutional resources—legal authorities, technical competence, and especially money—from higher to lower levels of government, from management agencies to affected local constituencies, tends to withhold responsibility and competence from local governments and bias the outcome in favor of project development values. Project subsidies and inconsistent cost-sharing arrangements between Federal, state, and local governments make it difficult for local interests to weight alternative policy choices properly on the basis of what they are willing and able to pay for them. Existing procedures promote agency responses to individual interests and make it difficult to tie policy choices to their comparative net social worth, *all* things considered.



THE LOCAL ROLE IN WATER POLICY

The policy guidance process in theory determines what needs to be said about resource management conflicts, and the institutional structure creates a voice, at appropriate levels, to say it. The nation's present water policy structure has a top-down rather than a bottom-up orientation. This is manifested in repeated legislative and administrative attempts to extract national policy guidance from collections of management agencies at the Federal level. That these attempts have not been successful is partly attributable to a conception of the policy process that emphasizes its role in imposing discipline from the top down without recognizing that it originates with affected interests from the bottom up. The consequence is continued public focus on the roles of the Federal government and the states in the process, where mission-oriented management agencies dominate, and comparative inattention to the role of local and substate regional governments, where water-using constituencies, or affected interests, dominate.

The local role in water policy tends to be limited in practice to public participation in project planning performed by the Federal construction or regulatory agencies and their state counterparts. Regional impact evaluations of management alternatives such as inter-basin water transfers or hydropower projects cannot fully satisfy the need for a broad policy guidance process for whole water resource systems when the scope of the analysis—and usually its outcome—are determined by the specific legislative mandates of the sponsoring agencies. Viewed in the context of the water policy process as a whole, "public participation" in agency planning begins not with the inception of a management plan but with the institution of a continuing policy guidance process.

If it were fully operational, the process might function as a separate component of an integrated water policy process under the overall guidance and control of public constituencies. Since policy emanates from affected interests, it could provide a tool that they can use to assert their values within all phases of the policy process and at all levels of the institutional structure, to guide and control management actions that affect their regional water resources systems cumulatively over time.

An important institutional barrier to national water policy is the uneven capability of the states to provide a state layer in the structure. A majority of the states lack statewide water policy, and in those states the determining factor may be the absence of a policy guidance process that is built from the level of cities and towns, counties, and substate regional planning agencies up to the state level. Recognition that state water policy constitutes the foundation for national water policy necessarily implies that the foundation for state policy—and for the structure as a whole—is local and substate regional policy.

At the Federal level the interagency coordinating apparatus established by the Water Resources Planning Act—the Water Resources Council—was unable to commit its member agencies to compliance with resource management policies contained in approved river basin plans. Congress provides legal authorities and financing for Federal water development projects and programs; underlying considerations seldom arise from a regional policy guidance process, or even, in many instances, from the management planning process.

ABOVE: A government that provides adequately for the development and application of policy guidance can antcipate and plan for future water supply, flood management, or other crises.

TOP LEFT: The conflict between the need to prevent loss of life and property damage from flood hazards in downsteam communities, and the need to prevent environmental and social disruption from dam construction in upstream communities, might be resolved by a policy that generally rejects dams in favor of local protection works or nonstructural measures.

BOTTOM LEFT: Resource conflicts beween navigation and commercial fishing interests create the need for guidanceand at the same time create the considerations — competing social values that arise from beneficial and adverse impacts — that will provide guidance.

The nation has developed detailed procedures for product-oriented water project planning and implementation but now needs to develop a continuing process for anticipating and resolving water policy conflicts from the local level up that considers their cumulative impacts on the resource base over time, and on the collective local and other interests who share the resource. How should the policy process be defined? How should the institutional structure for the flow of policy from lower to higher levels be designed? How should the institutional structure for the flow of resources from higher to lower levels be designed? What water policy process does the nation want, and what institutional support structure is needed to make it work?

If conventional research and political processes cannot address these issues adequately, how should the collaborative reform process and supporting institutional analysis be designed so that these issues can be adequately addressed? Who should participate and in what setting can their roles in the policy process be examined?

WATER POLICY STRUCTURE

The institutional structure for national water policy consists of three main components. One is the different levels of government. Another is the public and private sectors. The third is management agencies and public constituencies—the various water users and other interests served by the agencies and represented through elected officials. The performance of the institutional structure raises four basic questions about the allocation of organizational roles and relationships:

1. Does the nation have the organizational capacity to generate policy guidance for watershed management—does it have the capacity to *govern* regional water resource systems that cross state and local boundaries?
2. Does the nation have the organizational capacity at the national level to perform a policy guidance function?
3. Do management agencies and public interests have proper roles in the policy guidance function?
4. Do the states and local governments have the institutional infrastructure they need—the organizations, procedures, technical competence, and money—to assume greater responsibility for water policy and water resources management?

CAPACITY TO GOVERN WATERSHEDS

The definition of the policy guidance process used herein implies the need for an organizational role that is not generally found within the nation's river basins. Organizational arrangements developed for water resource management on a river basin scale, including Title II river basin commissions established under the Water Resources Planning Act, for the most part focus on management or project planning and usually are controlled by management agencies rather than local governments and other constituencies.

The organizational role that is generally missing potentially provides a foundation for the entire water policy structure. In theory it would perform a number of essential functions:

- Identify and resolve water policy conflicts at the lowest point possible in the organizational structure where this can be done within the context of unified river system management;
- Transfer conflicts up to higher layers in the structure that involve larger regional issues that go beyond the boundaries of the water resource system or are of larger than local or regional significance, such as inter-basin transfers or major industrial facilities;
- Link the policy guidance function with management planning and the project authorization and funding process;
- Integrate water with growth management, and conservation with economic development;

- Apply a comprehensive basinwide perspective to individual management decisions, giving due consideration to their cumulative impacts upon the water resources system over time and to the interests of the collective constituencies who share the watershed;
- Provide an appropriate institutional home for watershed constituencies through flexible arrangements for inter-local cooperation, and give them a means of speaking with one voice and dealing with other levels of the water policy structure. It is only among general-purpose local governments collectively that a perspective can be found that covers every aspect of river system management and that is not bound by the limited mandates of management agencies, by state boundaries, or by special interests;
- Create a base of local leadership at the inter-local level from which to build a watershed constituency;
- Provide a mechanism that allows local constituencies to assert their values and to assert appropriate control over the water policy process within their watershed, subject only to overriding considerations at higher levels in the structure;
- Provide policy guidance for the determination of water project priorities.

Rivers and their interconnected tributary systems, groundwater aquifers, and related lands are better managed as systems.

ORGANIZATIONAL CAPACITY AT THE NATIONAL LEVEL

A national water policy entity would have to represent broadly the different levels of government and other major interests that make up the structure as a whole to give it a national perspective on the issues. Congress is a lead water policy institution with a broad, national constituency. However, the National Water Commission found that its internal organization and procedures, particularly the Federal water project authorization process, tend to inject a fragmenting rather than a unifying influence into the policy process, and these conditions have remained essentially unchanged since publication of the commission's report (*Water Policies for the Future,* 1973).

The Cabinet Council on Natural Resources and the Environment, chaired by the president, provides a mechanism for Federal interagency coordination. It places the Federal water establishment more fully under the direction and control of the president than the Water Resources Council had been. It has a greater capacity to resolve major interagency conflicts than that council, but is viewed by non-Federal interests as being less accessible. The Cabinet Council is not designed to develop and implement national water policy. It represents elements of the Federal executive branch. It does not represent non-Federal interests such as the states and local governments and therefore cannot resolve policy conflicts between states or regions; apply policy guidance to promote intergovernmental cooperation; or assert a collective discipline over the entire national water policy structure in the *national,* as opposed to the *Federal,* interest.

Organizational changes that are under consideration in the Congress—specifically the creation of a national water policy board—raise the question whether an entity with a national perspective can be created through modifications to the Federal interagency apparatus established by the Water Resources Planning Act, or whether an entity that is more broadly representative of national water policy constituencies is needed. Specifically, would it be feasible to create an entity that represents state and local perspectives as well as Congress and the administration? That represents different regions, the private sector, environmental interests, and other perspectives? It is necessary?

ROLES OF MANAGEMENT AGENCIES AND PUBLIC INTERESTS

The Water Resources Council and Title II river basin commissions were said to be "all things to all people." They were given policy guidance and management planning responsibilities under the Water Resources Planning Act and were criticized alternately for doing too much of both or none of

LEFT: The nation's water policy structure has generally evolved piecemeal from specific needs, such as irrigation for agriculture and flood damage reduction, and governmental responses.

BOTTOM LEFT: The system has evolved largely in response to Federal categorical grant programs and project subsidies, which encouraged a damaging dependence on Federal grants and a distortion of the policy process.

either. The fault did not lie so much with their chairmen, their membership, their level of participation, their funding, or their personalities, as some have found. They were miscast.

Experience with the agency-based institutional structure established under the Water Resources Planning Act raises the question whether a policy guidance function can—or should—be combined with a management function in the same agency. For the Water Resources Council and river basin commissions were composed of management agencies, and were not representative of local governments or private interests. The assignment of primary policy guidance responsibility to the bureaucracy, rather than to representative, constituency-based institutions, violates basic democratic principles. It potentially alienates large segments of the institutional structure and undermines its political support. It could result in a demoralized bureaucracy as well as an unreceptive public.

The Water Resources Planning Act lost support perhaps because it demanded too much of management agencies and asked too little of public constituencies, particularly local governments. The agencies accepted their assignments and may have showed by their performance that their assignments placed them in an inappropriate role in the water policy process. The question this raises is how the relationship between management agencies and constituencies at all levels can be recast so that the contributions of each can be linked appropriately without being combined. What procedures and institutional forms will insure that the agencies' technical competence, powers, and institutional resources can be used to the fullest, without their encroaching on the public policy process? What arrangements will place the main actors in an appropriate relationship with one another so that the structure as a whole will increase its productivity and thereby increase the power of all of its components?

STATE AND LOCAL INFRASTRUCTURE

The Federal government has impeded institution building at the state and local levels through its generous water project subsidies and limited planning assistance. The system has evolved largely in response to Federal categorical grant programs and project subsidies, which encouraged a damaging dependence on Federal grants and a distortion of the policy process. Federal withdrawal provides an opportunity for the structure to evolve in different ways, from the bottom up.

A system where beneficiaries pay for water resource management is conducive to more local autonomy—to the development of a policy guidance process for water management controlled collectively by local governments and other interests that share regional water resource systems. Local governments in general are in a stronger position if they pay part of the cost. The water policy process and institutional support structure would be placed on a firmer footing if local governments did not rely entirely upon the states and Federal government to pay the costs.

Local constituencies that share regional water resource systems have a sensitive role to play in the water policy process but are poorly equipped politically, technically, and financially to assert their collective interests. Unless they receive encouragement, guidance, and assistance from higher levels, these systems may continue to constitute missing links in the policy structure and remain serious institutional barriers to national water policy.

Leadership would most logically come from state legislatures in establishing inter-local water policy structures within hydrological units. The states, in turn, need guidance, encouragement, and assistance from the Federal level to remove institutional barriers that now prevent them from doing this.

The present administration's shift away from Federal subsidies to private support for projects could open the way to new financing mechanisms for policy if means could be found to share project support with policy support. Can the creative thought that has been invested in finding private funding for water projects also find alternative sources of funding to support the water policy process? ■

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The National Water Supply: Its Impact on Availability and Cost of Water

by Steven L. Johnson and David E. Winslow

Most assesments of the national water supply have been either too gloomy or too rosy. Actual per capita water use is 10 times what was once supposed, but real shortage is one of water developments and waterworks, not water.

The future of the nation's water supply is a topic of frequent concern in the press, radio and television. Overly pessimistic writers imply or all but conclude that, within the foreseeable future, much of the U.S. will have dissipated is available water by consuming it or by grossly polluting it and that consequently industrial expansion must cease at one place or another, and social evolution wili retrograde. On the other hand, overly optimistic writers foresee no such scarcities withing the next several centuries. Such widely diverging opinions have come about by assuming that a given volume of water can be "used" only once (the pessimistic view) or can be reused an infinite number of times (the optimistic view).

Generally, the U.S. can be assured of sufficient water of acceptable quality for essential needs within the early foreseeable future, if it (1) follows prudent and rational management of all its natural water supplies; (2) is not expecting a simple solution for water supply stringencies that are emerging; (3) finds courage for compromise among potentially competitive uses for water; and (4) accepts and can absorb a considerable cost for new water-management works (Piper, 1965).

Although there is a tendency to take it for granted, water is one of the most important resources required for an industrial facility. The availability and cost of water is an important consideration for a facilities planner considering relocation or expansion of an industrial, agriculture, or commercial facility. The cost of water may be a small percentage of the total cost of a product; however, since the disruption of an adequate water supply may be permanent, it can be more devastating than a disruption of labor, raw materials, or energy. Of the resources required in an industrial process, water is one of the few that is renewable. In other words, the total supply of water is constant and can be reused time and time again, however, the amount available at any given place and time is highly variable. Because of this, costs can vary with respect to time and place and can even vary at the same location.

Even though availability and cost of water are important considerations for industrial growth, previous studies have failed to reveal any connection between water availability and growth in urban industrial areas. Studies by the National Water Commission (Rivkin/Carson, 1971) conclude that making water available cannot, in general, cause growth to occur. G.W. Howe (1960) found that water availability as measured by stream flow does not play a dominate role in determining growth. In 1960 Gilbert F. White concluded that the physical supply of water has not been a major factor in the location of industry in the U.S.

Are We Running out of Water?

Water supplies are not running out, but time is getting short to stem waste of water and destructive exploitation of the environment before harm is done that may be irreparable. Only a small part of continental water is available for use and management. The discharge of rivers to the sea is a close measure of the availability of liquid water, but groundwater reservoirs have important functions as inexpensive equalizers of water supply. Despite outcries of water shortage, the principal use of water in advanced countries is as a medium for disposal. U.S. supplies are adequate, given rational management. Contrary to common belief, water pollution is primarily a problem of economics, not health.

To total amount of water in existence is about 326,000,000 cubic miles. Discouragingly enough, somewhat more than 99.4 percent of this is brine and ice in

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oceans, inland seas, glaciers, and polar icecaps. It is difficult to visualize a million cubic miles of water or a tenth of one percent of a million. Analogy may give a better concept of these relative quantities. Let the total amount of water in existence be considered as one barrel-about 55 gallons. The ocean then may be represented as a tub containing slightly less than 55 gallons. Icecaps and glaciers would be a small block of ice equivalent of 1 gallon of water. Total water participating annually in the hydrological cycle appears as about 2 ounces in a small water glass. Annual precipitation on the land appears as half an ounce in a liquer glass. Fresh water discharged annually by rivers to the sea shows up as about 0.2 ounces in a small syringe. Annually recoverable ground water would be represented as a very small drop in a hypodermic syringe.

The total discharge of rivers is an approximate measure of potentially available and manageable liquid water in continental areas. The hydrological cycle has operated long enough in the modern climatic regime that the large amounts of water stored in lakes and underground are in quasi-equilibrium with water in other parts of the environment. In general, a lake is a delayed river—a natural equalizer of stream flow—and upstream removal of water from a lake depletes downstream flow. Natural underground reservoirs, the respositories of groundwater, also are equalizing reservoirs, and they are the principal regulators of natural streamflow. This comparison is oversimplified, but on a continental scale it is substantially correct. Groundwater developments that do not deplete streamflow are either water-mining operations that cannot be continued indefinitely, or they are local salvage from evaporation and are insignificant on the continental scale. Like their surface counterparts, however, groundwater reservoirs permit use of water at different temperatures and chemical properties than would be possible if dependence were solely on natural flow in rivers and delay in lakes.

Present water supplies are adequate in most parts of the world except those areas that are naturally and chronically arid or semiarid. But adequacy of supply is no guarantee of freedom from problems unless management is adequate. Water management is adequate when it correctly anticipates future problems and takes timely and suitable action to cope with them.

Groundwater reservoirs in North America may contain 2,000 to 3,000 times as much water as is present in river channels at any one time. They probably contain many times more water than can be stored in all the surface reservoirs that will ever be built on the continent. North American lakes contain about five times the amount of water discharged annually by rivers on the continent. In short, nature's plumbing system has built-in regulating devices that are far larger and far more effective than artificial ones. Surface-storage reservoirs, viewed in proper scale, are mere tinkerings with details of the plumbing system.

Groundwater reservoirs have several advantages. Properly managed, they do not flood valuable lowlands; evaporation rates are very low to nil; they do not silt up; they do not wear out. Many such reservoirs have tremen-dous unused capacity that someday may be used for storage of surface supplies. Full knowledge of these capabilities could well lead to more effective water-resource management than all potentials for manipulating streamflow by surface reservoirs.

Estimated Use of Water in the U.S.

Estimates of water use in the U.S. in 1970 (Murray and Reeves, 1972) indicate that an average of about 370 bgd (billion gallons per day)—about 1,800 gallons per capita per day—was withdrawn for the four principal off-channel uses, which are (1) public-supply (for domestic, commercial, and industrial uses), (2) rural (domestic and livestock), (3) irrigation, and (4) self-supplied industrial (including thermoelectric power). Industrial water withdrawals included 54 bgd of saline water. The fifth principal withdrawal use, hydroelectric power (an in-channel use), amounted to 2,800 bgd. In computing total withdrawals, recycling within a plant (reuse) was not counted, but withdrawal of the same water water by a downstream user (culmulative withdrawals) was counted. The quantity of freshwater consumed—that is, water made unavailable for further possible withdrawal because of evaporation, incorporation in crops and manufactured products, and other causes—was estimated to average 67 bgd for 1970.

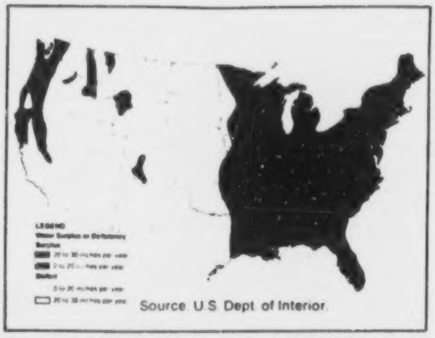
Water is not running out, but time is short to stem waste before irreparable harm is done.

Estimates of water withdrawn from the principal sources indicated that 68 bgd came from fresh groundwater, 1 bgd from saline groundwater, 250 bgd came from fresh surface water, 53 bgd came from saline surface water, and 0.5 bgd was reclaimed sewage.

The average annual streamflow—simplified measure of the total available water supply—is approximately 1,200 bgd in the conterminous U.S. Total water withdrawn in 1970 for off-channel uses (withdrawals other than for hydroelectric power) amounted to about 30 percent of the average annual streamflow: 7 percent of the 1,200 bgd basic supply was consumed. However, comparisons indicate that the rate of withdrawal was higher than the locally dependable supply in the 17 western states. Consumption amounted to nearly 25 percent of withdrawals in the conterminous U.S.; however, freshwater consumption amounted to only 14 percent of off-channel withdrawals in the 31 eastern states.

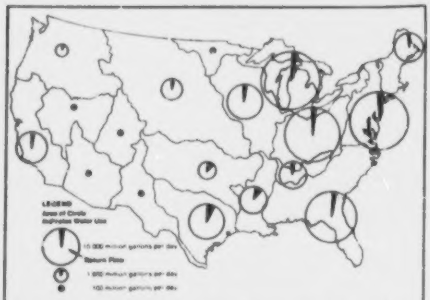
More water is withdrawn for industrial water use than for any other category of withdrawal use. The amount of self-supplied industrial water used in the U.S. and Puerto Rico in 1970 was estimated as 210 bgd of which about 54 bgd was saline. More than 80 percent of the industrial water was withdrawn in the eastern part of the U.S. (Figure 1). Water used by thermoelectric power-plants in 1970 constituted about 78 percent of industrial uses. Of the total water withdrawn by self-supplied industry, 90 percent of the water was used for cooling, and 25 percent of all self-supplied industrial water was saline.

No change in the relative proportion of source of supply was indicated in 1970, as groundwater again supplied about 5 percent, surface water 95 percent and reclaimed sewage only a fraction of 1 percent. The ratio of water withdrawn to water consumed was estimated to be approximately the same for fresh and saline water used by industry in 1970. For freshwater uses, water consumed was about two-thirds of a percent by thermoelectric



Source U.S Dept of Interior.

Figure 1. Self-Supplied Industrial Water Withdrawals by Regions in Millions of Gallons per Day.


LEGEND
Area of Circle
Indicates Water Use
10,000 million gallons per day
Return Flow
1,000 million gallons per day
100 million gallons per day

Source: Murray, C.R., and Reeves, E.B., *Estimated Water Use in the United States, 1970*, U.S. Geological Circular 676 (1972)

Figure 2. Water-Rich and Water-Poor Areas of the U.S.

plants, about 10 percent by other industries, and about 3 percent by all industries.

Murray and Reeves (1972) documented the quantities of water withdrawn and consumed in the U.S. from 1950 to 1970. The trend shows steady rates of increase in water use with only surface water used for irrigation showing an irregular trend. Trends established over the period 1960-65 did not change during the period 1965-70 and probably hold through today.

Generally, demand for water must be met by the locally available supply. The quantity available in some areas is much the same year after year, but in other regions unpredicatable differences occur that result in variations from year to year. In addition to the yearly differences, seasonal differences of available water are to be expected in most areas. Cumulative withdrawals decrease the streamflow, and return flows increase it, thereby producing a net balance of available surface supply at a given time and place. In order to compensate for the various irregularities in availability, water-resources management practices are established, such as storage of water in reservoirs and artificial groundwater recharge. Importation of water from regions with greater natural supplies is also practiced in some areas.

Murray and Reeves examined relationships of supply, withdrawal use, and consumptive use for the conterminous U.S. They found that the aggregated off-channel withdrawals (i.e., withdrawals for all purposes other than hydro-electric power) of fresh water in the conterminous U.S. are about 75 percent, and that consumption is about 20 percent, of the estimated dependable supply (435 bgd) for 1970. Two factors limit the usefulness of these figures—the cumulative, off-channel withdrawal totals represent to an unspecified degree a number of repeated withdrawals of the same water by different users, and the withdrawal data also represent national or regional averages and, therefore, hide local water shortages. Such shortages often lead to reuse, so that gross use can exceed the dependable supply; however, the recycling within a plant leads to increased consumption. Water that has been consumed is, of course, no longer available for reuse. Also, loss (consumption) of a large percentage of the water in any region may cause serious impairment (degradation) in the quality of the remaining water, and, in addition, the volume and flow of the remaining water may be insufficient for essential nonwithdrawal uses.

As long as there is no slackening of the rates of water withdrawal and water consumption, major attention must be given to water management problems so that maximum benefits will be obtained from use of the nation's water resources.

Types of Water Supply

The cost and availability of water at any location depends upon the type of supply. Various factors affecting the cost will be discussed later. Water supply can be roughly classified as in three general groups: (1) surface water, (2) groundwater and (3) ocean water.

Groundwater is probably the best water supply when available and obtained at the point of use. Since the supply is usually on-site and controlled by the user, operational costs and storage problems are minimal. Since the quality and temperature of groundwater is constant, it can be used within a manufacturing process with very little treatment costs. Groundwater is sometimes available from flowing artesian wells; however, facilities requiring large volumes of water will usually require pumps.

Surface water supplies the major portion of the industrial water used in the U.S. Surface water can be obtained directly from a stream. However, due to the variability of stream flow rate, additional storage reservoirs are usually required to produce a safe yield or guaranteed supply.

The last major supply is ocean water. Ocean water is usually acceptable for cooling water with the use of heat exchangers. Ocean water is used in some water poor areas to obtain fresh water supplies through distillation or reverse osmosis.

Factors Affecting Availability of Water

Generally, availability of water is highly dependent upon rainfall. As previously discussed, the real supply is measured as the amount of water flowing to the oceans. This is especially true for surface water supplies. Good groundwater supplies, however, can be obtained in areas of very little rainfall or streamflow. These supplies are usually dependent upon rainfall during previous centuries or on rainfall at some distant location. Rainfall is required to recharge the undergound reservoirs by infiltration through the soil or losses from stream channels. Groundwater withdrawal in excess of the natural recharge of the underground reservoir results in mining of water, and, in such cases, water is no longer a renewable resource.

The geology of the subsurface and the soil and vegetation cover of the surface are important factors affecting water supplies. Vegetative cover holds moisture and retards runoff, which allows water to percolate into the ground and to produce stream flow rates with less variability. When water is able to infiltrate to the subsurface, the amount of water stored in groundwater reservoir is dependent upon the geology. Porous limestone, sand, or gravel allows for the storage of large volumes of water. In many areas of the U.S., the aquifers can become saturated and discharge the excess groundwater into streams as springs. This results in a higher sustained stream flow rate with less variability. The phenomenon sometimes has very little correlation with rainfall. For example, at the turn of the century, before substantial groundwater development in Texas, the Devils River near Del Rio, in an area with an annual rainfall of less than 10 inches, had the highest minimum flow of any major river in Texas (T.U. Taylor, 1904).

Storage is the third important factor affecting water availability. Groundwater storage is affected by the geology as discussed above. Storage in natural lakes and man-made reservoirs is an important factor in the quantity of surface water available. Flow of the Saint Lawrence River exhibits the least variation between maximum and minimum flow of any river in the U.S. because of the storage withing the Great Lakes.

An indirect factor affecting availability is water quality, which affects its usability. Good quality for one use may be poor quality for another.

Factors Affecting Raw Water Costs

The above discussion briefly covers natural factors that impact the availability of water. These natural factors along with structural and mechanical requirements of development affect the cost of water. In consideration of raw water costs, the net cost must be considered, i.e., costs to the local community and the nation, as well as direct costs to the user. Table 1 presents a subjective summary of various costs for different types of water supplies.

The cost comparisons are applicable for large industrial supplies, where many millions of gallon per day are consumed. since this discussion covers the entire cost of water whether carried by the public or private sector, no consideration is given to costs associated with water rights, permit and regulatory constraints.

Groundwater. When available in quantities required, groundwater is the ideal supply. The user can usually control both the supply and the water plant required for the supply. Capitalization and energy costs are usually high when water is pumped from great depths. Distribution costs are usually low when the supply is located at the point of use. Treatment costs are usually low to moderate because groundwater quality is usually constant. There is no need to continually monitor the quality and make changes in the treatment process. Operation and maintenance cost for a water system supplied by groundwater is usually low.

Type of Supply	Capitalization Cost	Power Requirement	Distribution Costs	Operation of Plant and Treatment Facility
Groundwater	High	Moderate to High	Low	Low
Natural Sreamflow or Lakes	Moderate	Low	Low	Moderate to High
Surface Water Storage	Very High	Low	Moderate	Moderate to High
Springs	Low	Low	Low	Low
Untreated Ocean Water or Saline Lakes	Low	Low	Low	Moderate
Salt Water Distillate	Very High	Very High	Low to Moderate	High

Table 1. Raw Water Costs for Different Types of Water Supply.

Natural streamflow or lakes. The cost of obtaining a water supply from streams or lakes is relatively low. The pump plant will have lower capitalization costs per gallon required than groundwater supplies. Since the pumping head is low, power costs will be low. Assuming a user would locate near a stream or lake, distribution costs would be low. The treatment of a raw water supply from a stream may be high. If a good quality water is required, considerable operation costs will be required because stream quality is sometime highly variable, and usually requires continuous monitoring and changes in the treatment process.

Surface water storage. Factors affecting the cost of a supply from a reservoir are the same as those for natural streamflow and lakes discussed above, except for capitalization. Considerable expense is required to build dams, buy land, build conveyance systems and operate the system.

Ocean water and saline lakes. Untreated ocean water as well as highly saline inland lanes have a limited use. If water is required for cooling, this supply is generally low in capitalization, energy, distribution and operating costs. Some additional plant maintenance cost will be associated with corrosion due to the saline water.

Salt water distillation. This supply is the most expansive. It can only be justified for domestic supplies or drinking water for a light industrial plant. This supply will have a high capitalization cost, be a high energy user, and require high operating costs.

Areas with Abundant Water Supplies

A general knowledge of areas with sufficient water supplies should be helpful in planning industrial or commercial sites. This section presents information concerning the natural water supplies across the U.S. No attempt is made to delineate the existing usage, or areas in which prior water rights have been appropriated. Nor does this paper address the effect on these data due to power generation, navigation usage or environmental and regulatory constraints on the available supplies.

Surface water supplies. Figure 2 presents water-rich and water-proof areas within the U.S. One inch of runoff from one square mile is equal to 17 million gallons or 48,000 gallons per day.

Groundwater supplies. Throughout many areas of the U.S. good quality water can be obtained from wells in excess of 50 gallons per minute (gpm). Some of these aquifers are being used at or above their recharge rate, resulting in mining of water. Some of the aquifers are of

Type of Supply	Cost per Thousand Gallons	
	Low Range	High Range
Raw Groundwater	$0.08	$0.40
Treated Groundwater	0.20	0.60
Raw Surface Water	0.15	1.00
Municipal Supplies	0.40	1.25
Saline Distillation	2.00	5.00
Reclaimed Sewage Treatment Plant Effluent	0.15	0.30

Table 2. Range of Water Costs.

limited use for obtaining large quantities of industrial water.

Water costs

The cost of water to the industrial user is dependent upon a number of variables. The costs can vary considerably among locations and types of supplies. The quality requirement of the water can make a moderately priced raw water supply very expensive. Water costs were obtained from a number of users and suppliers. A review of the literature and publications provided additional cost data. The costs from various locations compiled at different times (different values of the dollar) using different assumptions indicated wide variability. All the cost data probably include capitalization price index. Table 2 presents the range of costs in various types of supplies in dollar per thousand gallons.

There is great variation among companies and firms in the quantity of process and cooling water required. One report (United Nations, 1976) found wide variability from product to product, from factory to factory, and from country to country. For example, to process a ton of sugar beets, the amount of water required per ton ranged from 475 gallons in Israel to 5,300 gallons in Finland. Water requirement for petroleum refineries range from 20 gallons per barrel of crude oil input to more than 1,000 gallons per barrel.

An indication to the impact of water cost in industrial use is the elasticity of demand. Elasticity indicates the presence of flexibility because the user is able to cut back use to offset rising prices, while inelasticity indicates very little flexiblity. Few studies are available to indicate the elasticity of industrial water demand. One British study indicates elasticity ranging from -0.96 (neither elastic nor appreciably inelastic) for chemicals, -1.95 for paper and pulp, -2.5 for building materials, -4.1 for beverages and -3.3 to -6.7 for foods. The average elasticity of demand for all industry was -2.86 (Rees, 1969). These values are for industrial water use in Great Britain but are probably applicable for the U.S.

A few industries possess little flexibility in water use. However, if water is available, the impact of increased cost is minimal because of small percentage of final product cost that is attributed to water. Water costs as a percent of total production costs were estimated for major water-using industries in the state of Washington. These estimates indicate: food and kindred products, 0.02 percent to 2.6 percent; pulp. 0.005 percent to 1.1 percent; paper, aluminum 0.14 percent to 1.15 percent; and petrolume, 0.18 percent. Another approximation is that total water utilization costs for industry in general ranges from 0.1 percent to 3.0 percent of total production costs (Bower, 1965). Even in the case of food processing, which incurs higher than average water costs, little locational impacts could be expected, because this industry exhibits greater than average elasticity of demand for water (Lord, 1982). Greater flexibility in water use per unit of output exists in almost all industries.

Restrictions and Constraints on Water Availability

As water problems become more acute in certain areas, regulations start playing an important part in water development. The root of these problems can be social, political, or hydrological, and, to some extent, it is generally all three. One problem usually leads to another, and ultimately some type of regulatory policy comes into play. Some of the restrictions and constraints on developing dependable water supplies are presented in the following case studies.

Groundwater interception. For many years Comanche Spring at Fort Stockton, Tex., was used to irrigate a large area of farm land. In the later 1940s ranchers north of the spring discovered that good wells could be devel-oped and the dry ranch land converted to prosperous farms. After a few years Comanche Spring stopped flowing and the farmers using the spring lost their irrigation supply . Litigation was started by users of the spring with no favorable ruling. Before the 1960s water law did not apply to groundwater in Texas, as in many other states. The water under a persons property was treated as a mineral right with no control or regulation on its use. The farmers above the spring were allowed to pump all the water they wanted even though they were intercepting an exisiting supply. If the laws affecting surface-water rights were applied to groundwater in the case of Comanche Spring, the users of the spring would have been protected. These type of problems have been recognized by the states in recent years. Recently, Texas has instituted laws that allow formation of underground water conservation districts and other governmental entities to control and regulate problems associated with groundwater development.

More critical uses. As times change, peoples ideas of the value and use of water change. In times of shortage, governmental action may take one user's water and give it to another. This is much like the emergency allocation of natural gas in the Northeast and Midwest, when supplies were cut off to factories and given to homes. The same thing could happen to water supplies. This problem can be minimized by carefully analyzing an area's water supply.

Interstate stream compacts. All streams that flow through, or border, two or more states are usually managed under the guidance of an interstate compact. The board of these compacts is usually made up of one representative from each state affected plus one or more federal representatives appointed by the President. Some of these compacts have been in existence for many years and still have not reached a final decision on the division of the water within an interstate stream. Sometimes the federal courts become involved in this litigation. In the early 1960s the courts gave a large quantity of the Colorado River water to Arizona. This water was being used by southern California. Based on this decision, Arizona started the Central Arizona Project to bring the Colorado River water to Phoenix and Tuscon. California had to go to the Feather River in northern California to obtain the supplies to replace the water lost to Arizona. Red Bluff Reservoir was bult in the mid-1930s on the Pecos River in Texas just below the New Mexico border. The reservoir was full one time in 1941. As a result of the Pecos River Compact Commission, most of the water in the Pecos River above Red Bluff Reservoir belonged to New Mexico. The reservoir is presently a mud flat with an occasional rise in the water level. However, no safe yield of water is available to the downstream agriculture areas that existed in the 1930s. These areas have returned to ranching or lie vacant.

Subsidence. Some areas of the U.S. are currently experiencing subsidence of the land due to groundwater withdrawal. As more water is pumped, the water level declines. This decline does not indicate that the supply of water is less, but it is a hydraulic fact that as more wells are drilled and more water pumped, the water level must drop. As the water level drops, previously saturated clay strata or layers located in the sand aquifer are dewatered due to declining water level. The clays are compressed, resulting in a decline in the ground surface. This problem is acute in Houston and Long Beach. A subsidence district was formed in the Houston area in the early 1970s to regulate and limit groundwater pumpage. A large surface water supply was developed on Trinity River, and is presently being used to supplement the industrial groundwater supplies. The industrial users along the Houston Ship Channel were required to convert to surface water supplies at a considerable cost.

Salt water intrusion. In coastal areas, a definite boundary exists between the salty ocean water and the fresh groundwater. The location of this boundary is affected by the geology of the subsurface, the rainfall recharge of the aquifer, and the salinity of the saltwater. The boundary between the saltwater and freshwater naturally move as the above conditions change. As water supplies are devel-oped in the area, the boundary becomes unstable. Water levels are drawn down as groundwater usage increases, causing the saltwater at the low depths to move inland. Poor planning can result in having a good water supply became salty and unusable. The southern Florida area is experiencing this problem. It is being controlled by importing water from the Everglades in canals and keeping the water level of the canals higher than the groundwater level, thereby placing an additional positive gradient (pressure) on the saltwater.

Sole source aquifers. The Edwards Limestone Aquifer under San Antonio has been designated by the Environmental Protection Agency (EPA) as a sole source of water for San Antonio. This regulation limits the activities on the recharge area north of San Antonio. While this is not a direct water supply problem or constraint, it could limit the use of property or limit expansion of activities of an existing facility. Care should be taken to determine if these type regulations could impact future long-range plans.

Estuary considerations. The impact of water resource development on the bays and estuaries has, in recent years, become a concern. The balance between saline water and freshwater within the estuary system is important to maintain productive fish populations. Due to this consideration considerable regulatory pressure may be exerted on further development within some river basins.

Interbasin transfer. In the West, there presently exists a number of interbasin transfers of water. Denver obtains part of its supply from the western side of the continental divide. Planners have, for a number of years, looked into the possibility of moving Mississippi water to the West, pumping Louisiana water to the high plains of Texas, and diverting the Columbia to the southeast for irrigation. These types of moves, however, probably would not impact present users. Still, consideration should be given to the possibility of such transfers in choosing to locate an industrial facilty.

Conclusion

For the United States as a whole, there is no shortage of water — only a shortage of waterworks and developments. Consideration of water problems solely as functions of streamflow and withdrawal use is an evasion of the real situation. Water needs per individual in industrial societies are nearly 10 times greater than had once been supposed. Paramount among water problems is that of maintaining good water quality. Only rational decision and payment of reasonable cost are required to cope with situations. The dominant shortage is of water development and waterworks, not of water.

In view of the universal prevalance of water problems, the world can ill afford to remain passive so long as it lacks means for fully effective management of its aggregate water supply. Management must assure both adequate quantity and good quality. No human crises centering around water exists today, but one is visible on the horizon.

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Issue Brief

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WATER PROJECT DEVELOPMENT: COST SHARING ISSUES

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BY

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ISSUE DEFINITION

One approach to make the Federal dollars in public works budgets go further is to increase the non-Federal cost share for new water projects. The Reagan Administration has emphasized this approach and both Houses of Congress have introduced bills containing cost sharing provisions for Corps of Engineers projects that would increase the non-Federal share for these projects. At issue is whether existing cost sharing arrangements are satisfactory, or whether new arrangements that would increase the non-Federal share, but could also permit Federal funding of more projects, are not more appropriate in times of budgetary restraint.

BACKGROUND AND POLICY ANALYSIS

The cost of most water projects is apportioned into a Federal and a non-Federal share. Federal water project construction agencies, such as the Corps of Engineers, the Bureau of Reclamation, and the Soil Conservation Service, contribute the Federal share of water projects. Local sponsors, such as State and local governments, cities, or counties, contribute the non-Federal share.

Most water projects are multi-purpose in nature. These purposes include flood control, navigation, water supply, hydroelectric power, recreation, irrigation, and area development. Often as many as four or five of these purposes are present in one project. A "patchwork quilt" of cost sharing arrangements for water projects has developed for a variety of reasons: each purpose has a different cost sharing formula; not all construction agencies have the same cost sharing formula for the same purpose; and Federal construction agencies use different financing arrangements (such as length of loan repayment and interest rate).

Existing cost-sharing formulas for each purpose are established by law and have evolved over a long period of time. These formulas vary, depending upon the project purpose and the Federal agency involved. For example, the non-Federal cost-share for the construction of the hydroelectric power component of a project is 100% for all the construction agencies, while the non-Federal cost share for the recreational component of a project is 50% for most agencies. The Federal construction agency responsible for a project computes the non-Federal cost share and provides the local sponsors a loan for the non-Federal share. The local sponsors are required to repay the loan plus interest on a repayment schedule specified by the construction agency (usually 30 to 50 years) and provide written assurance that they will do so.

Different Federal construction agencies, however, might have different cost sharing arrangements for construction related to the same purpose. Thus for the recreational component of a water project, if the Corps of Engineers or the Bureau of Reclamation were the construction agency, the non-Federal share would be 50% but if the Soil Conservation Service were the construction agency, then the non-Federal share would be 100%.

To complicate cost sharing matters further, financing arrangements can make the composite non-Federal cost share different than the non-Federal cost share specified by law. Examples of financing factors are the interest rate on the loan, the number of interest-free years, length of the loan repayment or "reimbursable" period, requirements for "up-front" payment of non-Federal share of projects, the interest during construction, the magnitude and terms of the transfer accounts, the value of in-kind contributions (such as land, easements, rights-of-way), and the calculation of the OM&R of the costs of the project.

An example of how these financial factors can influence the composite non-Federal cost share can be seen in the interest rate and repayment policies of the Bureau of Reclamation for the irrigation component of a water project. The Bureau does not require "up-front" payment of the non-Federal share of its loans. Instead, the loans are reimbursable over a repayment period of up to 50 years. Furthermore, the Bureau charges no interest on the repayment of the reimbursable loan. These financing arrangements could represent substantial savings to the local sponsors of the irrigation component of a project.

An important background factor in the cost sharing debate of the 98th Congress was the linking of new Corps of Engineers project authorizations to cost sharing proposals. The pressure to authorize new Corps projects had increased steadily every year for the last 8 years since enactment of the last "omnibus" water project authorization bill in 1976. In the absence of authorization of any "new starts" since 1976, all annual water projects appropriations funding had gone to continued construction of existing Corps of Engineers projects and OM&R.

The debate of the 98th Congress did not focus on Bureau of Reclamation projects. The Bureau projects, contained within major planning "units," have been authorized on a more regular basis. A "unit" is the Bureau's large-scale hydrologic planning area and usually includes many water projects within it. Bureau "units" and the projects within them are authorized through different committee jurisdiction than Corps of Engineers projects. While Congress has authorized some projects within previously authorized Bureau "units," no major new "units" have been authorized recently.

Reagan Administration Interest in Cost Sharing. As part of its "New Federalism" approach to water resources policy, the Reagan Administration initiated an effort in its beginning years to decrease the fiscal role of the Federal Government in water resources management. Specific elements of this effort would have included increasing the non-Federal cost shares for various purposes in multi-purpose projects and requiring "up-front" financing of the non-Federal share by the local sponsors, rather than local sponsors repaying the Federal loan over a designated payback period.

Another element of the "New Federalism" approach in water project development was to showcase water projects that would exemplify the new cost sharing arrangements. Testifying before the House Appropriations Energy and Water Resources Subcommittee in May, 1982, the Assistant Secretary of the Army for Civil Works, William Gianelli, sought to reprogram FY83 funds to enable the Corps of Engineers to begin construction on nine new hydroelectric and flood control projects exemplifying the new cost sharing principles. Collectively for the nine projects, local sponsors would have paid for more than 75% of the project costs. Congress, however, would not authorize these new projects until cost sharing and user fee legislation had been enacted.

The Administration, however, appears to have relaxed somewhat its rigorous approach of increased non-Federal cost sharing for all construction agencies. Instead, it has adopted a more flexible approach, which, on the one hand, encourages each agency separately to negotiate reasonable financing arrangements for every project, and, on the other hand, requires consistency within a Federal agency in cost sharing for individual water projects purposes (letter dated Jan. 24, 1984, from President Reagan to Senator Laxalt).

One possible outcome of this new position is that individual agencies will retain existing cost sharing arrangements. Another possible outcome is that project sponsors using "creative financing" cost sharing arrangements with an increased non-Federal cost share and "up-front" payment of the non-Federal cost share would have their projects viewed more favorably for Federal funding.

But final problems for this "creative financing" possibility are the current congressional cost sharing initiatives. At this point, it is difficult to predict whether new cost sharing initiatives will pass, and if so, in a form which is similiar to existing cost sharing arrangements, or a form incorporating some of the "New Federalism" approaches.

Congressional Water Development Procedures. Congress selects water projects through the two-phase authorization and construction appropriations process, that follows preliminary congressionally mandated studies indicating the technical feasibility of the project. In the authorization phase, Members of Congress vote to accept new water projects grouped in an "omnibus" rivers and harbors bill. Typically, only through a specific amendment to this bill can a Member vote on an individual project. To qualify for inclusion in the authorization bill, a project normally must have a benefit-cost (b-c) ratio greater than unity. Water project construction agencies determine the b-c ratios of projects. Congress historically enacted water projects authorization legislation every 2 years, although the most recent authorization enactment was in 1976.

After the authorization phase, Congress then selects certain authorized projects for the construction appropriations phase. Again, this is a process where Members of Congress typically vote up or down on a list of projects reported by the Appropriations Committees. Construction appropriations normally occur annually, but only for the incremental amount needed for the next year's construction, and not for the full cost of the project. For a number of reasons, Congress does not fund construction of all authorized projects. The reasons include technical problems, funding priorities, increasing environmental and other "grass-roots" opposition, and diminishing congressional support for a project between authorization and construction. For the authorized Corps of Engineers projects that repeatedly are not funded, Congress has deauthorized projects through the authority of section 12 of P.L. 93-251 since 1975.

Activities of the 98th Congress

The 98th Congress included new cost sharing proposals in bills (H.R. 3678 and S. 1739) which would have authorized new Corps of Engineers water projects. Appropriations for these new projects, contained in separate legislation (H.R. 3958), were contingent upon passage of authorization and cost sharing legislation.

The House-passed version of H.R. 3958 proposed funding 44 water projects, 20 not yet authorized, and 24 previously authorized but which had not yet received any construction monies. The House report (H.Rept. 98-373) linked funding of authorized as well as unauthorized water projects to enactment of the cost sharing proposals contained in H.R. 3678.

Unlike the House-passed bill, the Senate-reported version of H.R. 3958 did not directly link funding of the water projects to passage of cost sharing legislation. The Senate report (S.Rept. 98-274) on H.R. 3958 expressed concern about "overzealous application of rigid cost sharing requirements" and recommended a "flexible approach" to cost sharing provisions contained in S. 1739. The projects recommended for funding in the Senate version overlapped, to some extent, with those recommended in the House-passed bill. The Senate Committee, however, recommended deletion of 20 projects included in the House-passed bill. The 98th Congress never completed action on H.R. 3958. Nonetheless, it did enact measures for funding continuing construction projects: P.L. 98-50 provided FY84 money and P.L. 98-360 provided FY85 money.

Activities of the 99th Congress

The principal cost sharing proposals for Corps of Engineers projects in the 99th Congress are contained in H.R. 6, S. 366, and S. 534. The House bill, as introduced on Jan. 3, 1985, is the same as the H.R. 3678 of the 98th Congress. S. 366, introduced Jan. 31, 1985, is the same as the water project bill which was attached to the continuing resolution of the 98th Congress, then deleted (see Congressional Record, Oct. 3, 1984: 13222). S. 534 is the bill backed by the Administration. Generally speaking, non-Federal cost sharing percentages are higher in the Senate bills than the House bill.

Table 1 compares the cost sharing provisions currently in existence for Corps of Engineers projects and those proposed in H.R. 6, S. 366, and S. 534. All these bills contain cost sharing provisions for port development, flood control, urban water supply, hydropower development, recreation, inland waterways, and fish and wildlife mitigation.

For many of these purposes -- such as urban water supply, hydropower, and recreation -- the non-Federal cost sharing percentages in both the House and Senate bills are the same as those for existing Corps of Engineers projects. For other purposes -- such as port development, inland waterways navigation, flood control, and some cases of fish and wildlife mitigation -- the non-Federal cost sharing percentages in both the House and Senate bills are greater than those for existing Corps of Engineers projects. In these cases where the non-Federal percentages are greater, the Senate bills generally proposes higher percentages than the House bill. For agricultural water supply, however, the Senate bills proposes a decreased non-Federal cost share.

In port development, the existing non-Federal cost share is zero. In H.R. 6, the non-Federal construction cost share is zero up to 45 feet harbor depth and 50% of the incremental costs beyond 45 feet. Reimbursable loans to the non-Federal sponsors would be available from the Port Infrastructure Development and Improvement Trust Fund, which would be financed through customs duties collected during the previous fiscal year, but not to exceed $2 million dollars. Fund monies would be available for port development feasibility studies, relocations of utilities, structures, and other improvements for port projects, and for making reimbursable payments to non-Federal sponsors. The non-Federal planning cost share would be zero if the project is up to 45 feet deep, and 50% if the project is deeper than 45 feet. The non-Federal OM&R cost share for a general cargo port (up to 45 feet) is zero, while for a deep draft port (greater than 45 feet) this share would be 50% of the additional costs incurred by deepening beyond 45 feet. Two other House bills -- H.R. 45 and H.R. 50 -- also contain proposals for port development cost sharing.

For port development in S. 366, the non-Federal construction cost share would be 30% for projects up to 45 feet deep, and 100% for projects deeper than 45 feet. The non-Federal OM&R cost share would be the same as in the House bill. A 90% Federal loan guarantee would be available for the non-Federal share.

Under S. 534, the non-Federal share for planning, and construction, for general cargo ports would be 70%. For deep draft ports, the non-Federal share for planning and construction would be 70% for the portion up to 45 feet deep, and 100% for the portion greater than 45 feet deep. For the O&M of ports, the non-Federal share for shallow-draft projects of less than 14 feet is 70%, while the non-Federal share is 100% for projects greater than 14 feet. Non-Federal monies would be deposited in the Treasury as part of the Rivers and Harbors Contributed Fund.

In flood control, the existing percentage is 0 to 20% for Corps projects, depending upon the nature of the project. In the House bill, the non-Federal percentage varies from 25% to 30%. If lands, easements, and rights-of-way do not equal 25% of project costs, the non-Federal sponsors must pay the difference to the Federal Government over a 15-year period. If these items exceed 25%, then the non-Federal share is that percentage, up to 30%. In the Senate bill, the non-Federal percentage is 35% up-front. Under S. 534, the non-Federal share for flood control is also 35%, to be paid up-front, consistent with the ability to pay.

In urban water supply, the House and Senate bills require the same non-Federal cost share of 100% as that required in existing Corps projects. S. 366 authorizes appropriations of increasing amounts for loans for the rehabilitation of urban water supply systems: $200 million for FY86, $400 million for FY87, $600 million for FY88, $700 million for FY89, and $800 million for FY90. One-half of the loan funds for each fiscal year initially would be allocated among the States in proportion to each State's population, and the remainder of the loan funds would be allocated to individual projects at the discretion of the Secretary of the Army. S. 534 does not propose a similar loan program.

In urban water supply, the House bill authorizes $800 million annually, for each of the three fiscal years 1985 through 1988, to be appropriated for loans for the rehabilitation of urban water supply systems. The loans would not exceed 80% of the cost of rehabilitation. The maximum amount of a loan would be $40 million for the rehabilitation of any water system, or $80 million for projects in any one State. Unlike the Senate bill, no funds will be allocated to the States on the basis of a formula. Instead, the Secretary of the Army would review all applications made for these loans, recommending approval or disapproval of each. The Secretary would then submit a list of such applications, together with the recommendation for each, to the House and Senate Public Works Committees. The Committees would then make the final approval (or disapproval) of the loans.

In inland waterways, the existing non-Federal construction cost share is zero. It should be noted, however, that contributions to the Inland Waterways Trust Fund -- financed by user charges -- provide revenues which help finance some of the current O&M for inland waterways. The user charge is in the form of a fuel tax. The fuel tax currently is at $0.08 per gallon and is expected to increase to $0.10 per gallon on Oct. 1, 1985.

For the House bill, the non-Federal construction cost-share for inland waterways would be, on paper, zero, but in actuality would be 33 and 1/3% if one considers that one-third of the Federal share would be financed through the Inland Waterways Trust Fund. For S. 366, the non-Federal construction cost share would be 100%. Loans for the non-Federal cost share, however, would be made available through the Inland Waterways Trust Fund. S. 534 contains no new provisions for inland waterways transportation.

In fish and wildlife mitigation, the existing non-Federal share is 25%. Under the House bill, the non-Federal cost share would be zero, and the Federal costs of mitigation would be financed through Environmental Protection and Mitigation Fund, which is authorized to receive $35 million under the House bill. Under S. 366, the non-Federal cost share would vary between zero and 33 and 1/3%, depending upon whether the benefits are national or local.

Like the existing Corps of Engineers projects, most of the non-Federal construction shares in both the House and Senate bills are reimbursable. The only "up-front" non-Federal payments required are for the House bill's flood control purpose (existing arrangements for Corps projects require "up-front" non-Federal payments), where land, easements, and rights-of-way (LER) may be used as credit for this non-Federal share, and local sponsors may reimburse the Federal Government any difference in value between LER and the minimum non-Federal share over a 15-year period. In S. 534, the non-Federal sponsors normally will pay their share up-front. However, for flood damage reduction, hurricane, and storm damage reduction, recreation, and agricultural water supply, non-Federal payment will be up-front but consistent with the non-federal sponsors ability to pay at that time.

TABLE 1: Non-Federal Cost Sharing Percentages for Water Project Construction, as Currently Practiced (Corps of Engineers), and as proposed in H.R. 5, S. 366, and S. 534 in 99th Congress

Purpose	Non-Federal Cost Share							
	Existing (Corps)		H.R. 6		S. 366		S. 534	
	%	Terms	%	Terms	%	Terms	%	Terms
Port development								
planning								
general cargo	0	--	0	RB, Fund	50	--	70	RB, Fund
deep-draft	0	--	0-50	RB, Fund	100	--	100	RB, Fund
construction								
general cargo	0	--	0	RB, Fund	30	RB	70	RB, Fund
deep-draft	0	--	0-50	RB, Fund	100	RB	100	RB, Fund
O & M								
general cargo	0	--	0	RB, Fund	0	RB	100	RB, Fund
deep-draft	0	--	0-50	RB, Fund	0-50	RB	100	RB, Fund
shallow draft	0	--	--	--	--	--	70	RB, Fund
Flood control	0-20	UF	25-30	UF	35	RB	35	UFAP
Water supply								
urban (mun. & industrial)	100	RB	100	RB	100	RB	100	UF
agricultural	100	RB	--	--	35	RB	35	UFAP
Hydropower								
construction	100	RB	100	RB	100	RB	100	UF
O & M	100	--	--	--	100	--	100	UF
Recreation								
construction	50	RB	50	RB	50	RB	50	UFAP
O&M	100	--	100	--	--	--	100	UFAP
Inland waterways	0	--	0-33	RB	100	RB	--	--
Fish and wildlife construction	25	RB	0	Fund	0-33	RB	100	UF
Hurricane and storm damage	--	--	--	--	--	--	35	UFAP
Aquatic plant control	--	--	--	--	--	--	50	UF
Feasibility studies (all)	--	--	--	--	--	--	50	UF

LEGEND:
RB = reimbursable
UF = up-front
UFAP = up-front consistent with ability to pay

-- = not mentioned

LEGISLATION

H.R. 6 (Howard)

Contains cost sharing provisions for water projects, as well as authorizations for new water projects. Introduced Jan. 3, 1985; referred to Committee on Public Works and Transportation.

H.R. 45 (Biaggi)

Authorizes new cost sharing formulas for port development. Introduced Jan. 3, 1985; referred to Committee on Merchant Marine and Fisheries.

H.R. 50 (Mikulski)

Authorizes new cost sharing formulas for port development. Introduced Jan. 3, 1985; referred to Committee on Merchant Marine and Fisheries.

S. 366 (Abdnor)

Contains cost sharing provisions for water projects, as well as authorizations for new water projects. Introduced Jan. 31, 1985; referred to Committee on Environment and Public Works.

S. 534 (Stafford, by request)

Authorizes new non-Federal cost sharing formulas for port development, and projects which include purposes such as hydroelectric power, municipal and industrial water, recreation, flood damage reduction, hurricane and storm damage reduction, agricultural water supply, fish and wildlife enhancement, and aquatic plant control. Introduced Feb. 27, 1985; referred to Committee on Environemnt and Public Works.

A CBO STUDY

Efficient Investments in Water Resources: Issues and Options

Congress of the United States
Congressional Budget Office

EFFICIENT INVESTMENTS IN WATER RESOURCES: ISSUES AND OPTIONS

August 1983

Congress of the United States
Congressional Budget Office

PREFACE

Over the last 150 years, the federal government has gradually accepted responsibility for most of the costs of developing the nation's water resources. Federal investments have provided valuable services to a developing nation, including navigation on inland waterways and coastal ports, irrigation of western lands, flood control in all major river basins, and hydroelectric power primarily in the West and South.

Today, with a more mature national economy and with most nationally important water projects in place, the need for a strong federal role in new water development is less compelling. The most likely future water resources needs--maintenance of existing facilities and new construction of local projects--could be met more efficiently if states, local governments, and direct beneficiaries had a greater responsibility for project costs, financing, and selection.

This study analyzes three options that are under Congressional or Administrative consideration. Each recognizes the changing nature of water development responsibilities and aims to combine cost-sharing reform with financing mechanisms and changes in decisionmaking processes that, taken together, would promote a more efficient water resources investment program. The Congressional Budget Office (CBO) has prepared this report at the request of the Water Resources Subcommittee of the Senate Committee on Environment and Public Works. In keeping with the CBO's mandate to provide objective analysis, this paper offers no recommendations.

Kenneth Rubin of CBO's Natural Resources and Commerce Division prepared this study, under the supervision of David L. Bodde and Damian J. Kulash. The author wishes to thank Everett M. Ehrlich, also of the CBO, for his support and valuable commentary; and Dr. Peter Rogers of Harvard University, Dr. Kenneth Frederick of Resources for the Future, and Dr. Gerald E. Galloway, Jr. of the U.S. Military Academy for reviewing and commenting on the manuscript. Patricia H. Johnston edited the manuscript, assisted by Nancy H. Brooks. It was prepared for publication by the ever-cheerful Angela Z. McCollough.

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August 1983

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SUMMARY

Widespread support is beginning to develop for fundamental redirection of the federal government's water resources policies. Traditionally, the federal government has played a major role in choosing, financing, and paying a large share of the costs of water projects. In contrast, the responsibilities of state and local governments and private users have been relatively small. This extensive federal participation was appropriate for the early development of the nation's major river basins, waterway transport systems, and western regions. It appears less so today as water investment priorities continue to shift from construction of new projects toward the management, repair, and modernization of facilities now in place and to projects of increasingly local character. The Congress, therefore, faces the task of reorienting federal water policies to conform to these changes.

Two components are central to any such policy reorientation. The first is greater state and local responsibility for project costs, financial arrangements, and project selection. The second is increased user fees to recoup those portions of project cost that provide private rather than public benefits. Taken together, these policy changes could lend strong incentives to states, local governments, and private beneficiaries to work with the federal government to ensure that the most cost-effective projects are built and maintained.

Many legislative approaches to carry out such a reorientation are possible. This paper concentrates on three that appear closest in intent and structure to those that have recently been considered by the Administration or the Congress:

- Establishing a self-sustaining federal loan fund to replace annual appropriations for local water resources projects.
- Replacing federal grants for projects of local interest with block grants to states, allowing greater local choice of investments.
- Targeting the remaining federal project grants toward water projects that are national in character.

ORIGINS OF THE FEDERAL ROLE--DEVELOPMENT AND PUBLIC GOODS

The federal role in water resources originated in the early 1800s, largely out of a concern for the nation's regional development and economic growth. Toward these ends, the federal government built a network of inland waterways to provide transport services to developing regions. The federal government also built and maintains a system of inland and coastal ports to aid commerce and provide for the national defense. Since 1902, the federal government has built almost 700 dams to provide water and power to help settle the West. And in the 1930s, the federal government began to develop the water resources of an entire river basin--the Tennessee--to stimulate economic growth in the South.

To promote growth and regional development, the federal government has paid an average of 70 percent of the combined construction and operating costs of such projects, leaving states, localities, and private users to carry the remaining 30 percent. Such subsidies have even been extended to cover some of the costs of providing marketable water services. For example, the federal government pays 94 percent of the cost of inland water transport services, 81 percent of irrigation water and recreation services costs, 84 percent of harbor dredging, and 64 percent of municipal water and hydroelectric power generation. The remainder of the costs are borne by nonfederal participants (see the Summary Table).

High federal shares of costs have also been justified on grounds that the federal government was the appropriate supplier of nonmarketable water services--termed "public goods"--such as flood prevention, fish and wildlife enhancement, or water quality control. These services benefit the public at large, but they offer no fiscal incentive to invite private investment. The federal government took on major responsibility for these often heavily capital-intensive undertakings for two reasons. First, until recently, few states had the fiscal capacity to afford such projects. Second, public benefits often accrued to clusters of neighboring states, leaving no single state with the incentive to pay for the development. Thus, since the 1930s, the federal government has paid between 80 and 90 percent of the costs of flood control dams, up to 97 percent of water quality control costs, and about 85 percent of fish and wildlife preservation costs.

SHIFTING NEEDS AND SHORTCOMINGS OF CURRENT POLICY

Although public benefits remain valid as a motivation for major federal involvement in providing nonmarketable water resources services, the continued subsidization of marketable products and services (for which user charges are appropriate), together with federal payments for public

SUMMARY TABLE. EFFECTIVE NONFEDERAL COST SHARES OF FEDERAL WATER RESOURCES DEVELOPMENT, BY PURPOSE AND AGENCY (In percents)

Project Purpose	Army Corps of Engineers	Bureau of Reclamation	Soil Conservation Service	Weighted Average of all Federal Water Agencies
Urban Flood Damage Reduction	17	a/	a/	20
Rural Flood Damage Reduction	7	10	27	11
Irrigation	19	18	54	19
Municipal and Industrial Supply	54	71	100	64
Hydroelectric Power	61	65	b/	64
Water Quality Control	3	82	b/	60
Fish and Wildlife Preservation	11	13	57	14
General Recreation	17	18	63	19
Inland Waterways	6-11 c/	7	b/	6
Commercial Harbors	16	b/	b/	16
Agency Mean	20	37	49	30

SOURCE: Adapted by Congressional Budget Office from Water Resources Council data.

a. Agency reported a cost category for this purpose but not cost sharing.

b. Agency reported no activity for this purpose.

c. Receipts from the fuel tax implemented pursuant to the Inland Waterway Revenue Act of 1978 could increase the nonfederal share to as much as 11 percent from the Water Resources Council's 1974 calculation of 6 percent.

investments of state or local interest, appear to create rather than solve problems.

Since the inception of many water resources programs, the United States has reached economic maturity, and the development objectives of many original water resources policies are now largely accomplished. The inland waterway system, for example, is well-established and needed coastal harbors are built. The West, once unsettled, now has a mature industrial and agricultural base. Most major interstate river basins have been developed to meet the needs of past generations. Water policy now confronts different objectives--namely, the maintenance and rehabilitation of water resources structures and services that are already in place and construction of new projects of mainly local importance, with user support when feasible. Further, many states that once lacked the fiscal capacity to finance their own water services have grown in economic strength. Finally, the cost-sharing, financing, and management arrangements stipulated under current policy no longer mesh well with these changing circumstances.

Economic Distortions

Federally subsidized marketable water services tend to be undervalued and overconsumed by users. This stimulates demand for continued subsidies rather than promoting cost-effective, user-supported investments. Federal water subsidies, for example, have resulted in irrigation of farm land at costs per acre far in excess of that land's productive value. In effect, general taxpayers pay for irrigation projects that beneficiaries would not support if water fees reflected the full cost of development. Moreover, federal subsidies--hence, low prices for water--blunt western farmers' incentive to conserve water and encourage cultivation of water-intensive crops, such as cotton or rice, in arid regions. For example, southern growers, who would otherwise have a natural competitive advantage in growing cotton, are forced to accept lower prices and reduced returns as cotton production continues to shift to western states. Similarly, subsidies to freight shippers on the inland waterways amount to more than one-fourth of the costs of the barge industry, many times the federal subsidy to competing freight modes, such as railroads, trucks, and oil and gas pipelines. By encouraging the use of barges, this subsidy stimulates demand to build more locks and dams with federal dollars. Thus, proportionately more of the cost of freight is transferred from direct users to general taxpayers.

State and local governments may experience similar incentives for overconsumption of nonmarketable water services subsidized by the federal government. While self-financed flood control projects may never be realistic, communities have an incentive to overvalue flood-protected land so long as flood protection is perceived as an essentially "free" good. In such cases, the costs of flood control can exceed the real development value of flood-free land. Moreover, federal provision of flood-prevention structures discourages communities from exploring more cost-effective alternatives.

Policy Issues

A great deal of evidence suggests that water resource investments could be made more cost-effective and equitable if they depended more on users and states for financial support. To these ends, the Congress confronts three basic policy issues.

Project Selection. Investment decisions are now made by the Congress based, in part, on requests from state or local governments or private beneficiaries and, in part, on engineering, environmental, and economic analyses performed by the federal water agencies. This system, however, offers little guarantee against undertaking projects of questionable merit. Higher cost shares for users and for local governments would provide incentives for greater local involvement in project selection, more realistic project evaluation, and, therefore, more cost-effective investments. For projects of national significance, an independent review board could avoid the lengthy process (as long as 28 years) that now characterizes the evolution of many water projects.

Project Financing. Federal financing without repayment requirements can perpetuate current subsidies. Yet strict reliance on state financing could prevent the construction of some needed projects, especially in relatively poorer states. This suggests that a mix of federal and state financing would best serve the goals of efficiency and equity.

Cost Sharing. Inefficiencies created by subsidies to direct beneficiaries and to state and local governments could be reduced if cost-sharing policy were based on two conventions. First, direct beneficiaries should pay for marketable benefits consumed, and second, all levels of government should share the costs for water projects that provide nonmarketable benefits.

FEDERAL POLICY OPTIONS

The water resources policy options considered in this report are representative of recent proposals under Congressional consideration. Each option would place greater responsibility for project selection, financing, and repayment on states, local governments, and direct beneficiaries. This emphasis could provide greater incentives than current policy to work with the federal government to ensure that the most cost-effective projects are built and maintained, and to provide an equitable distribution of government services. But this shift in responsibility would also affect the federal and state budgets and private-sector beneficiaries of public works projects.

Federal Loan Program

Rather than continuing the dominant federal role in financing and decisionmaking for local water projects, a federal loan program could be used to increase nonfederal responsibility. Federal loans would provide up-front capital for state and local investments. These loans would be repaid from user fees, to the extent that marketable benefits are provided, and from state funds for half of the nonmarketable benefits. Though financed with federal loans, these projects would be selected and managed at the state or local level. Nationally important projects, on the other hand, would continue to be selected, financed, and operated by the federal government, with costs recovered through federally administered user fees when applicable.

Investment Efficiency. The availability of federal loans would ensure the ability of all states to build needed local projects, even if they were unable to finance such projects themselves. The federal loans would not be committed until the applying state met two conditions: establishment of a cost-recovery system based on user fees for projects with marketable benefits; and state acceptance of legal responsibility to repay at least half the cost of all projects with nonmarketable benefits. This approach would focus user support on the most needed projects, based on realistic, unsubsidized prices of water and water-related services. Similarly, those projects perceived by state governments to have the highest public return on their investments would be promoted first. This would allow states and localities to choose their own local investments without undergoing the time-consuming process demanded by current policy.

Projects of national importance could be selected by an independent federal and state review board, subject only to Congressional appropriations. Such a board might be freer to judge the economic merits of an investment without being subjected to the political pressure that is now brought to bear on the Congress by special local interest groups.

Effects on Federal and State Budgets and Users. The potential efficiency gains of a federal loan program must be balanced against three effects. First, in the early years, before state and user payments began to accrue, high state financing demand could deplete the loan fund, putting budgetary pressure on the federal government. Federal capital outlays could increase from the fiscal year 1982 level of $2.3 billion to over $4 billion if water resources projects that extend beyond current policy were undertaken. In time, this problem would diminish as user fees and state repayments replenished the fund. Second, although a loan program would accommodate the repayment capacity of most states, it would impose additional burdens on the states, including new financial responsibilities for project evaluation, management, and cost recovery. Finally, recipients of marketable benefits would have to pay substantially more for such services or reduce their consumption. Many users might have to accept reductions in services because of increased costs.

Federal Block Grants

Under block grants, states would again take the lead in selecting local projects. Each year, the Congress would appropriate investment funds for distribution to the states, based on population, land area, or other measures of "need." A state could use the federal funds apportioned to it for local water projects, provided that the state financed half the projects' costs. States would have the option, but not the requirement, to recover their investment with local user fees. The federal government would continue to finance projects of national importance, selected by an independent federal and state review board. Federally administered user fees would recover federal expenditures when appropriate.

Investment Efficiency. Under block grants, economically efficient intrastate projects would be less assured than under the loan program option. This would occur because user fees would not be mandatory, and states could choose to subsidize groups of users if they so desired. States would be encouraged to institute user fees for intrastate projects, however, because of their increased financing responsibilities. Interstate projects, on the other hand, would be conditioned by users' willingness to pay appropriate fees, thus helping to guide federal investments toward projects with the greatest return. Interstate project selection by an independent review board would also help ensure cost-effective federal spending.

Effects on Federal and State Budgets and Users. Under the block grant option, the 1982 level of federal appropriations for water resources--about $3.7 billion for construction and operations--could have generated a total of about $5.2 billion in combined federal and state investments. Such potential gains in efficiency, however, would have to be balanced against the increased state financing burden implied by matching grants. Under this block grant approach, states would have to raise

50 percent of the cost of the average water project before work could begin, compared to the current practice of repaying about 30 percent of project costs, sometimes over a 50-year period aided by user payments. This could result in only the wealthiest states' building water projects. In addition, shippers using the inland waterways would pay user fees, which in turn could eliminate traffic on some routes, reduce farm incomes during slack markets, and cause local economic dislocations.

Federal Project Grants Under A Limited Federal Role

Under this option, the federal government would give states the full responsibility for new local projects--selection, financing, and cost recovery (at their discretion). The federal government, on the other hand, would continue to select and finance projects of national significance as determined by an independent review board. Financial and administrative responsibility for all currently operating and authorized local projects would be transferred to the states over a period of ten years. Any new projects that were interstate or international (affecting Canada or Mexico, for example) in scope or contained national security implications would be constructed under current financing conventions. But federally administered user fees would be instituted to recover appropriate portions of project costs. Receipts from such fees would accrue to the federal government and to the states in proportion to their financing contributions.

Investment Efficiency. Federally administered user fees would match costs to beneficiaries, thus linking new federal investments with users' willingness to pay and reducing the tendency for overinvestment. Federal funds would no longer support projects of mostly local significance, and these freed federal resources could be redirected toward other national needs. The states, faced with financing and paying for intrastate water projects, would have a stronger incentive to make priority investments first, recovering their costs through state user fees as they saw fit. The absence of federal financing, however, could prevent the construction of some worthwhile projects in economically depressed states. In such cases, opportunities for cost-effective investments could be lost.

Effects on Federal and State Budgets and Users. This option would place the greatest financial pressure on the states through added costs of operating and managing existing intrastate projects, financing new intrastate projects, and meeting current cost-sharing requirements for nationally important projects. For example, if this option was in place in 1982, out of about $3.7 billion in federal expenditures for water resources that year, about $1.5 billion, or 41 percent, would have been a state responsibility. Transferring this responsibility to the states over ten years, however, could reduce sudden financial burdens and allow more time for states to develop new programs. Two types of states would be at a relative disadvantage under this option: those that have relied most heavily on federal subsidies or technical expertise, and those with the least ability to raise development capital. Many activities of federal agencies would revert to the states, including small watershed improvement projects of the Soil Conservation Service, local flood control projects and some port dredging undertaken by the Corps of Engineers, and up to 40 percent of the Bureau of Reclamation's construction activities. As in the other options, users of inland waterways and nationally important ports would pay more for navigation services than they now do.

CHAPTER I. INTRODUCTION

The appropriate federal role in developing and managing the nation's water resources has been a contentious issue facing the Congress since the federal government first assumed responsibility for navigation projects in 1826. Over the years, federal policies for selecting and sharing the costs of water projects have responded to the needs of an expanding industrial and agricultural economy. Federal water development objectives have included regional economic development, national defense, and creation or preservation of noneconomic benefits that the private market would not otherwise supply. To achieve these national objectives, the federal government has assumed most of the responsibility for financing and paying for water projects. Because many of the early water projects served interstate needs, decisionmaking has become centralized at the national level.

The Congress has always recognized that water projects are investments and that the expenditure of public resources should return the greatest possible net benefits to the nation. But this principle--often referred to as economic efficiency--has never been fully integrated into federal water development programs. Only recently have attempts been made to formally incorporate the efficiency principle into water development guidelines. After 150 years of building federal water projects, new projects are diminishing in favor of more efficient operation, maintenance, and rehabilitation of existing water projects. Most of the large, federally important water projects were built over this period, and remaining construction needs are focused on smaller intrastate projects.

With this transition in water resource needs, it seems logical to expect the way the federal government deals with these needs to change also. Federal water policies put in place to stimulate development cannot be expected to address the emerging Congressional concern for economic efficiency. In this regard, the three most important policies for current Congressional consideration are water project cost sharing, financing, and decisionmaking. Taken together, high federal cost assumption and complicated administrative processes for evaluating and selecting projects are the source of most of the inefficiency in federal water resources development programs.

PLAN OF THE PAPER

Chapter II presents background information on federal water resources programs, roles of the federal agencies and the Congress, and current water project cost-sharing policies. Chapter III documents the underlying changes in water development priorities. In Chapter IV, the economic efficiency objective is defined as it applies to water resources investments and in terms of implications for changing water project cost-sharing conventions and decisionmaking processes. Chapter V evaluates three options that could lead to a more efficient investment program for water resources.

CHAPTER II. FEDERAL WATER RESOURCES DEVELOPMENT POLICIES

Although about 20 federal agencies are, to a degree, responsible for about 30 kinds of water resources development, four agencies account for most federal activity: the U.S. Army Corps of Engineers (Corps), the Bureau of Reclamation (Bureau) in the Department of the Interior, the Soil Conservation Service (SCS) in the Department of Agriculture, and the Tennessee Valley Authority (TVA). Together, these agencies and the Congress make most of the water project investment decisions with limited nonfederal input. This chapter presents background information about the water development authority of these four agencies, their water project cost-sharing policies, and the roles these agencies and the Congress play in the decisionmaking process.

HISTORY OF FEDERAL WATER PROGRAMS

All water resources investments originated as state or local responsibilities, but as the nation expanded and water problems entered into national consciousness, new federal programs were developed to deal with those problems. 1/ Federal intervention has been justified principally on grounds of promoting regional economic development.

Navigation

The Gallatin Report of 1808 proposed a nationwide, federally subsidized system of navigational canals and locks and dams, justified on grounds of economic development of the West and on national defense needs. The nation's rivers were considered the principal means of transportation linking westward expansion with the more developed eastern half of the country. Thus, federal authority for constructing the inland waterways and ports and harbors began with the first Omnibus Rivers and Harbors Act in 1826. This and successive Rivers and Harbors Acts have enabled the Corps of Engineers to develop a navigational improvement program for construction, operation,

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1. See Beatrice Hort Holmes, A History of Federal Water Resources Programs, 1800-1960, U.S. Department of Agriculture Miscellaneous Publication No. 1233 (June 1972).

and maintenance of the inland waterways system, including navigational locks and dams and maintenance dredging of the nation's ports and harbors. In fiscal year 1974, the federal share to complete all authorized water projects, termed "exposure," would have been about $40.5 billion. 2/ Of that total, waterway projects accounted for 16 percent and commercial harbor projects for about 3 percent (see Table 1). In fiscal year 1982, the Corps spent about $1.3 billion to construct and operate inland navigation and commercial harbor projects (35 percent of 1982 combined water resources appropriations of the four main federal water agencies).

Flood Control

Flood control remained a local concern until the 1860s when the Corps of Engineers recommended extensive construction of flood control levees in the Mississippi Valley to protect new settlements. The rationale for federal intervention was the uncoordinated, ineffective local protection efforts and projected costs beyond the financial capability of the states and localities. The Corps' flood control activities expanded as the country grew and eventually incorporated the multiple-purpose reservoir concept (impounding stream flow for irrigation, navigation, recreation, hydroelectric power, and municipal water supply as well as for flood control).

At about the same time, in the late 1940s, the Soil Conservation Service was given the authority to construct smaller, upstream flood control structures in conjunction with its assistance program to local agricultural

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2. The remaining federal cost to complete an authorized project is defined as exposure. In 1975, the Water Resources Council compiled federal exposure by project purpose based on 4,796 projects that were authorized as of 1974 (see Options for Cost Sharing--Part 5A, Planning and Cost Sharing Policy Options for Water and Related Land Programs, November 1975). Some of these projects were active, but others had been authorized as early as 1884 and never acted upon. Though incomplete, this data base was a blend of then-contemporary needs and historical federal priorities. Today, the total federal water project exposure--about $60 billion--is roughly equivalent to the 1974 level after accounting for inflation. The current allocation of total federal exposure among project purposes is also roughly equivalent to the 1974 allocation, because no new projects have been authorized since 1976.

TABLE 1. DISTRIBUTION OF FEDERAL WATER RESOURCES CAPITAL EXPOSURE AS OF FISCAL YEAR 1974, BY PROJECT PURPOSE

Project Purpose	Capital Costs (In percent)
Waterways	16
Commercial Harbors	3
Urban Flood Damage Reduction	21
Rural Flood Damage Reduction	19
Irrigation	7
Hydroelectric Power	6
Municipal and Industrial Supply	4
Water Quality Control	8
Fish and Wildlife Preservation	2
General Recreation	7
Other	7

SOURCE: U.S. Water Resources Council, Options for Cost Sharing—Part 5A, Planning and Cost Sharing Policy Options for Water and Related Land Programs (November 1975).

organizations. Today, all four federal water agencies build flood control works. Flood control projects accounted for about 40 percent of the total federal capital exposure for authorized water projects as of fiscal year 1974 (see Table 1). In fiscal year 1982, about $1.3 billion in federal expenditures were made for this purpose (35 percent of 1982 combined water resources appropriations of the four federal water agencies).

Irrigation

With the passage of the Reclamation Act in 1902, the Bureau of Reclamation was given the responsibility for developing western water resources for irrigation and later for hydroelectric power. The purpose of the act was to promote economic development of the West and settlement of western public lands by offering inexpensive federally developed water and power to family farmers. Originally, western farmers were to repay the entire federal investment without interest (using a revolving fund) over ten years. But, costs escalated and many farmers could not meet their repayment obligations. As a result, several acts between 1902 and 1939 relaxed the original financial terms and established the present "ability to pay" criterion. By 1980, 161 irrigation and related projects had been constructed or authorized by the Bureau. Irrigation projects accounted for about 7 percent of the total federal capital exposure for authorized water projects as of fiscal year 1974 (see Table 1). Over the last ten years, annual Bureau spending for irrigation has accounted for about 6 percent of annual combined water resources appropriations of the four main water agencies.

Hydroelectric Power

Prior to 1906, hydroelectric power projects were undertaken by private parties, sometimes with federal permission (if on navigable waters) or under special federal leases for use of surplus water. But in that year, the Secretary of the Interior was authorized to develop hydroelectric power at reclamation projects. In 1912, the Corps was given discretionary authority to add water power provisions to navigation dams. Five years later, the Flood Control Act of 1917 required the Corps to include hydropower provisions as part of flood control dams when economical. In 1933, the TVA was empowered to exercise all federal water and power functions on the Tennessee River system, including the construction and authorization of hydroelectric power projects. Today all three agencies plan, construct, and operate hydroelectric power facilities. In fiscal year 1974, these projects accounted for about 6 percent of the total federal water project exposure (see Table 1).

Multiple Purpose River Basin Development Under the TVA

During the 1930s depression, the federal government created the Tennessee Valley Authority to promote economic development of an entire river basin--the Tennessee River system--by constructing facilities for flood control, navigation, and hydroelectric power generation. By 1953, the TVA had built 20 multiple-purpose dams on the Tennessee River mainstem and major tributaries. In 1981, the TVA operated 25 multiple-purpose dams, and nine single-purpose hydroelectric power generation facilities with total water resources appropriations of about $67 million. The TVA spent about $25 million in fiscal year 1982 for constructing new water resources projects (multipurpose dams, flood control facilities, navigational facilities, and recreational facilities).

Environmental Enhancement

Toward the late 1950s, the federal government again expanded its role in water resources development by embracing environmental enhancement objectives--water quality control, recreation, fish and wildlife development, ecological protection, and municipal water supply. The four federal water agencies together have obligated a relatively small percentage of their annual construction and operation budgets for these five purposes. For example, as of fiscal year 1974, the federal exposure for these agencies on the five environmental purposes combined accounted for only 14 percent of the total federal exposure (see Table 1).

CURRENT COST-SHARING POLICY

No unified national policy exists for sharing water project costs among the federal government, state and local governments, and direct users. Cost-sharing conventions have been shaped incrementally for each federal water agency through a series of federal statutes and administrative rules dating back to the turn of the century. Consequently, federal shares for the same type of water project differ among the federal water agencies. Within a given agency, cost-sharing rates can also vary for different technical solutions to the same water resources problem. There are two ways of viewing current cost-sharing rates: in terms of nominal cost-sharing rates, that is, those named in authorizing or policy legislation; and in terms of effective, composite cost-sharing rates that represent actual cash or contributions-in-kind paid by each participant over the project life. Effective nonfederal rates are generally lower than nominal rates.

Nominal Cost-Sharing Rates

Nominal cost-sharing rates vary widely from program to program and from agency to agency primarily because of 80 years of incremental water policymaking (see Table 2). For example, cost-sharing rates and terms for rural flood damage reduction were established for the Corps in 1928 and 1936, for the Bureau in 1940 and 1956, and for the SCS in 1954 (see Table 3). In addition, the Congress has often added new cost-sharing provisions, or made special exceptions, each time new projects were authorized. New provisions rarely replaced older ones; usually, they were added on, creating inconsistent, often confusing sets of rules and regulations.

Corps of Engineers. Under current policy, nonfederal cash contributions are not required for commercial navigation projects (ports, harbors, and waterways); structural flood control projects (reservoirs, levees, flood walls, and the like); hydroelectric power projects; water supply components of multipurpose reservoirs; or joint costs of fish and wildlife enhancement, recreation, or water quality features of multipurpose projects. Up-front cash contributions are required from nonfederal sponsors to cover 25 percent of separable fish and wildlife costs (for example, fish hatcheries) and 50 percent of separable recreation costs (such as boating or swimming facilities). For Corps projects, nonfederal sponsors are required to provide necessary land easements and rights-of-way. On average, they have accounted for 14 percent of urban flood control capital costs, 5 percent of rural flood control capital costs, 14 percent of port development costs, and 5 percent of inland waterway project capital costs. Nonfederal participants must repay within 50 years the capital costs of providing water supply storage and hydroelectric power.

The Corps pays all operation and maintenance (O&M) costs for navigation projects, major flood control reservoirs, and joint costs of multipurpose reservoirs. Nonfederal sponsors pay O&M for all other types of projects--local flood control, drainage, hydropower, water supply, irrigation, and separable cost of multipurpose reservoirs.

Bureau of Reclamation. Up-front cash payments are not specifically required from nonfederal sponsors of Bureau projects. [3] Minimum non-

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[3] An exception to this rule occurred in the Colorado River Basin Project Act Amendments of 1982 (P.L. 97-373), which required that nonfederal interests make up-front contributions of 20 percent of selected features of the Central Arizona Project. Local farmers supported this requirement and sought private financing in the bond market.

TABLE 2. CURRENT NOMINAL NONFEDERAL CAPITAL COST-SHARING RATES, BY PROJECT PURPOSE (In percents) a/

Project Purpose	Corps of Engineers	Bureau of Reclamation	Soil Conser-vation Service	Weighted Average 20 Federal Agencies
Urban Flood Damage Reduction b/	0-20	--	--	17
Rural Flood Damage Reduction b/	0-20	0-20	0-20	12
Drainage	50	--	50	41
Irrigation	50	0-20 c/	50	64
Municipal and Industrial Supply	100 d/	100 d/	50	81
Water Quality Control	0	25	e/	24
Fish and Wildlife Preservation	0-25 f/	25	50	20
General Recreation	0-50 g/	50	50	22
Commercial Harbors b/	0	--	--	10
Inland Navigation b/	0	--	--	5
Hydroelectric Power	100 d/	100 d/	--	74

SOURCE: U.S. Water Resources Council, Options for Cost Sharing--Part 5A (November 1975).

a. Tennessee Valley Authority (TVA) data excluded. There are no nominal cost-sharing requirements for TVA projects comparable to those for the other agencies. TVA repayment terms are based on selling electric power rather than on the traditional procedure of allocating costs by project purpose. See explanation in text.
b. Nonfederal participants must contribute necessary land, easements, and rights-of-way, which in dollar terms could total as much as 20 percent of total project capital costs.
c. Variable according to "ability to pay," but generally less than 20 percent.
d. Repayment only, financing not required.
e. Not established.
f. Nonfederal share of direct separable costs is 25 percent.
g. Nonfederal share of direct separable costs is 50 percent.

TABLE 3. MAJOR FEDERAL LEGISLATION AUTHORIZING COST SHARING, BY PROJECT PURPOSE

Project Purpose	Affected Agency	Authorizing Legislation
Urban Flood Damage Reduction	Corps	Flood Control Act of 1936 (P.L. 74-738)
		Flood Control Act of 1938 (P.L. 75-761)
Rural Flood Damage Reduction	SCS	Watershed Protection Act (P.L. 83-566)
	Corps	Flood Control Act of 1936 Flood Control Act of 1938 Flood Control Act of 1928 (P.L. 70-391)
	Bureau	Small Projects Act (P.L. 84-984) Reclamation Projects Act of 1939 (P.L. 76-260)
	TVA	TVA Act (P.L. 73-017)
Drainage	SCS	Soil Conservation Act (P.L. 40-460) Watershed Protection Act
	Corps	Flood Control Act of 1944 (P.L. 78-534)
Irrigation	SCS	Soil Conservation Act Watershed Protection Act
	Corps	Flood Control Act of 1944 Reclamation Act of 1902 (P.L. 57-161)
	Bureau	Small Projects Act Reclamation Projects Act
Municipal and Industrial Water Supply	SCS	Watershed Protection Act

(Continued)

TABLE 3. (Continued)

Project Purpose	Affected Agency	Authorizing Legislation
Municipal and Industrial Water Supply (Continued)	Corps	Water Supply Act of 1958 (P.L. 85-500)
	Bureau	Small Projects Act Reclamation Projects Act
Water Quality Control (Point Source)	Corps	Federal Water Pollution Control Act of 1972 (P.L. 92-500)
Fish and Wildlife Preservation	SCS	Watershed Protection Act
	Corps	Flood Control Act of 1944 Water Resources Protection Act of 1965 (P.L. 89-072) Water Resources Development Act of 1974 (P.L. 93-251)
	Bureau	Water Resources Development Act of 1974
Ports and Harbors	Corps	Rivers and Harbors Act of 1920 (P.L. 66-263)
Inland Waterways	Corps	Rivers and Harbors Act of 1920
	TVA	TVA Act
Hydroelectric Power	Corps	Flood Control Act of 1944
		1937 Bonneville Power Act (P.L. 75-329)
	Bureau	Reclamation Projects Act
	TVA	TVA Act

SOURCE: U.S. Water Resources Council, Options for Cost Sharing—Part 8D, Planning and Cost Sharing Policy Options for Water and Related Land Programs (November 1975).

federal shares are established by project type, but those shares may be paid with any combination of cash, contributions-in-kind (land, easements, rights-of-way), or repayments over time. For irrigation projects, capital costs are repaid (without interest) based on a calculation of farmers' ability to pay, which generally covers only about 10 percent of total project capital costs. Nonseparable capital costs allocated to fish and wildlife and recreation costs for facilities located on federal land are paid by the federal government. Operation and maintenance of all Bureau projects are the responsibility of nonfederal participants.

Soil Conservation Service. Prior to construction of any SCS project, a project agreement document must be signed by the responsible nonfederal entity endorsing that the following three conditions are satisfied:

- All land affected by the project will be purchased by or is already owned by the responsible nonfederal entity.
- The appropriate nonfederal share is secured in an escrow account and is available for payment of construction costs as performed and billed.
- Operation and maintenance will be performed and paid for by the nonfederal entity.

The nonfederal capital share of most SCS projects is 50 percent, except for structural flood control (0 percent) and nonstructural flood control (20 percent). 4/

Tennessee Valley Authority. There are no nominal cost-sharing requirements associated with TVA projects comparable to those of the other three federal water agencies. The TVA Act, as amended, established repayment terms for federal outlays based on selling electric power rather than on the traditional procedure of allocating project costs to purposes and recovering portions of those costs according to specific nonfederal cost-sharing rates.

The Amendments of 1959 required two types of payments to the U.S. Treasury from net power proceeds: a return on the federal appropriations

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4. Structural flood control entails building structures to contain flood waters or otherwise prevent flood damages (dams, levees, dikes, flood walls). Nonstructural flood control reduces flood damages without building structures (zoning against floodplain development, early warning and evacuation systems, flood-proofing buildings).

for power facilities and repayment of the dollar amount of invested capital. The amount of return payable each year, beginning in 1961, is based on the appropriation investment at the beginning of that year and the average interest rate payable by the U.S. Treasury on its total marketable public obligations as of the same date. The capital repayment schedule was fixed at $10 million per year between 1961 and 1965; $15 million per year between 1966 and 1970; and $20 million each year thereafter, until a total of $1 billion had been repayed to the U.S. Treasury. As of the end of 1982, a total of $370 million of the capital debt had been repayed. Return on appropriation investment totaled about $1.2 billion as of 1982.

Effective, Composite Cost-Sharing Rates

Nominal cost-sharing rates reflect the intent of water resources legislation regarding who should be responsible for paying the costs of water projects. But nominal rates provide little information about who actually pays how much over the project life. Effective, composite cost-sharing rates do exactly that by accounting for capital repayment subsidies, such as repayment without interest (irrigation projects); interest-free start-up periods (water supply, hydropower, and irrigation); and low, fixed-interest rates over long periods of time (all projects). In a single project rate, effective, composite cost shares reflect the ultimate cost burden on all participants by combining capital contributions, the cash value of contributions-in-kind, and the discounted present value of annual operating costs.

For example, consider a Bureau project with a capital cost of $14 million that is financed entirely by the federal government. The project would provide irrigation, municipal and industrial (M&I) water supply, and fish and wildlife benefits. The irrigation component costs $8 million and is to be repaid by the local sponsor in full over 50 years without interest. The M&I component costs $3 million and is to be repaid in full over 50 years at an interest rate of 6 percent. Fish and wildlife costs ($3 million) are not repaid by the local sponsor. All operating costs, about $100,000 per year, are paid locally. Thus, the local sponsor would pay $11 million of the $14 million project, for a nominal capital cost-sharing rate of 79 percent.

By contrast, the effective, composite cost-sharing rate would be much lower in this example. The federal government would pay an interest subsidy equal to $5.5 million for the irrigation purpose—the discounted present value of a 50-year loan of $8 million at a real interest rate of 6 percent. In addition, the federal government would pay the fish and wildlife cost of $3 million for a total effective federal contribution of $8.5 million. Nonfederal costs include the present value of irrigation payments without interest, M&I payments with interest, and all O&M payments. These total $7.1 million.

Effective, composite cost-sharing rates were calculated using this methodology for almost 4,800 joint federal and state water projects based on a 6 percent discount rate and a project life of 50 years (see Table 4). [5] For all types of water projects, the mean, nonfederal effective, composite cost share is 30 percent; or over the average life of a given water project, the federal government pays 70 percent of all costs and the nonfederal participants pay 30 percent. Nonfederal participants pay the least for navigation projects--7 percent of total project costs; and they pay the most for hydroelectric and municipal water supply projects--64 percent in each case.

Comparing Nominal and Effective Capital Cost Sharing

Effective nonfederal shares of capital costs are generally lower than nominal shares because of long repayment periods with fixed interest rates that tend to be low relative to the government cost of capital, provisions for interest-free "start up" periods, forgiveness of interest entirely during repayment, or the transference of cost from a reimbursable purpose to a nonreimbursable purpose (see Table 5). Low effective nonfederal cost-sharing rates imply a large federal financial responsibility and, potentially, federal subsidies. Large disparities between nominal and effective cost-sharing rates could indicate a cost-sharing outcome different from that originally intended by the Congress. For example, cost sharing for both inland navigation and irrigation projects involves substantial federal subsidies, but the nominal rate for navigation projects is close to the effective rate. The nominal nonfederal share of building a Corps' irrigation project is 50 percent while the effective share is only 15 percent. Most of this subsidy results from three practices: basing capital repayment terms on a calculation of ability to pay rather the actual cost of service; allowing other beneficiaries (hydropower or municipal water users) to pay irrigation costs, thus creating a cross-subsidy; and forgiving entirely the interest on federal capital outlays. These practices were not the original intent of the 1902 Reclamation Act; rather, they have been added in subsequent legislation.

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5. Although cost-sharing rates were calculated on the basis of 1974 data, no new projects have been authorized since 1976 and no new cost-sharing arrangements have been established. Only the effect of using a different interest rate would change these calculations if made today. A higher interest rate would have the effect of decreasing the nonfederal share of most types of projects. See U.S. Water Resources Council, Options for Cost Sharing--Part 5A, Planning and Cost Sharing Policy Options for Water and Related Land Programs (November 1975).

TABLE 4. NONFEDERAL MEAN, EFFECTIVE, COMPOSITE COST SHARING FOR THE CORPS, BUREAU, AND SCS, BY PROJECT PURPOSE (In Percents)

	Nonfederal Mean, Effective, Composite Share			
Project Purpose	Corps	Bureau	SCS	20 Agencies
Urban Flood Damage Reduction	17	a/	a/	20
Rural Flood Damage Reduction	7	10	27	11
Drainage	35	b/	58	46
Irrigation	19	18	54	19
Erosion Control	5	b/	89	34
Municipal and Industrial Supply	54	71	100	64
Water Quality Control	3	82	b/	60
Fish and Wildlife Preservation	11	13	57	14
General Recreation	17	18	63	19
Commercial Harbors	16	b/	b/	16
Inland Navigation c/	6	7	b/	6
Hydroelectric Power	61	65	b/	64
Agency Mean	20	37	49	30

SOURCE: U.S. Water Resouces Council, Options for Cost Sharing--Part 5A, Planning and Cost Sharing Policy Options for Water and Related Land Programs (November 1975).

a. Agency reported a cost category for this purpose but did not report cost sharing.

b. No activity reported for this purpose.

c. Receipts from the fuel tax implemented pursuant to the Inland Waterway Revenue Act of 1978 are not included; therefore estimates may be slightly low.

TABLE 5. A COMPARISON OF AVERAGE NOMINAL AND EFFECTIVE NONFEDERAL CAPITAL COST-SHARING RATES, BY PROJECT PURPOSE (In percents) a/

Project Purpose	Corps		Bureau		SCS	
	Nominal	Effective	Nominal	Effective	Nominal	Effective
Urban Flood Damage Reduction	0-20	14	b/	b/	19	15
Rural Flood Damage Reduction	0-20	5	0-20	0	0-20	19
Drainage	50	30	b/	b/	50	52
Irrigation	50	15	0-20	10	50	48
Municipal and Industrial Supply	100	54	100	68	50	100
Water Quality Control	0	0	25	99	b/	b/
Fish and Wildlife Preservation	0-25	7	25	4	50	51
General Recreation	0-50	14	50	11	50	58
Commercial Harbors	0	16	b/	b/	b/	b/
Inland Navigation	0	6	b/	b/	b/	b/
Hydroelectric Power	100	63	100	63	b/	b/
Agency Average	25	18	89	31	43	43

SOURCE: U.S. Water Resources Council, Options for Cost Sharing--Part 5A, Planning and Cost Sharing Policy Options for Water and Related Land Programs (November 1975).

a. Average values are weighted within purposes by allocated cost.

b. No activity for this purpose.

Both the hydroelectric power and municipal and industrial water supply purposes have large disparities between nominal and effective cost-sharing rates. Stated policy for federal water resources cost sharing for these two purposes calls for full recovery of all capital and operating costs through the sale of vendible products. 6/ High nominal nonfederal cost-sharing rates attest to this. After compensating for interest rate and repayment period subsidies, however, the actual result is a rather large federal subsidy--38 percent in the case of municipal and industrial water supply and 36 percent for hydroelectric power development.

Effective nonfederal capital shares are sometimes greater than nominal shares (for example, Corps inland navigation projects or SCS recreation projects). This is because the cash value of land easements and rights-of-way allocated to these purposes can account for up to 20 percent of overall project capital costs. In general, total nominal and effective operation and maintenance cost-sharing rates are equivalent because the nonfederal participants either pay all operation expenses on a cash, pay-as-you-go basis (irrigation projects, for example) or they pay none of these costs (as in large flood control reservoirs or navigation projects).

FEDERAL WATER PROJECT DECISIONMAKING

Historical Development

Early in the history of federal water resources development, the need for an efficient decisionmaking process was less acute, since needs were large and the costs of the water projects were considered small relative to the development benefits they produced. But over time, as the major water projects were completed and the federal water agencies began to explore marginal development projects, it became apparent that some measure of preference was needed to select the best water projects. So the Congress, in the Flood Control Act of 1936, introduced a benefit/cost standard for evaluating water development proposals. The act stated: ". . . the benefits to whomsoever they may accrue (must be) in excess of the estimated costs." For almost 30 years, the federal water agencies individually developed methods to calculate costs and benefits of water projects; there was little

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6. For additional details, see U.S. Army Corps of Engineers, Digest of Water Resources Policies and Authorities (March 27, 1981); and U.S. Bureau of Reclamation, Reclamation Instructions, Part 116, Economic Investigations.

coordination and even less consensus over appropriate analyses or economic assumptions. In the late 1970s, this effort was finally coordinated by the U.S. Water Resources Council, which issued a set of standards for evaluating costs and benefits of a proposed water project. 7/ These standards were never fully incorporated into federal water planning procedures, however. In 1983, the "Principles and Standards" were replaced by nonbinding "Principles and Guidelines" that emphasize project evaluation based on national economic benefits.

The result of such an evaluation is a benefit/cost ratio (B/C), used by the Congress to confirm the economic integrity of a proposed project. For reasons that are discussed in Chapter IV, however, a benefit/cost ratio is a relatively blunt instrument for separating more economic from less economic projects. As a result, federal funding often depends more upon the outcome of prolonged Congressional bargaining than on a project's economic merits.

A Multistep Decision Process

The process for evaluating and selecting water projects is lengthy and complex, involving approval of several offices in an executive agency, at least three trips to the Office of Management and Budget (OMB) and to Congressional committees for further approval, an act of Congress in most cases, and a Presidential signature. 8/ The average time between project evaluation and the end of construction is 26 to 28 years. The three most important steps of this process are: preparation of the feasibility report, project authorization, and project appropriations.

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7. Between 1979 and 1981, the Water Resources Council published sections of "Principles, Standards, and Procedures for Planning Water and Related Land Resources," commonly called the P&S. Methods were developed to quantify national and regional economic development benefits of water projects. In addition, the P&S outlined procedures to evaluate environmental quality benefits and other social effects.

8. For a detailed account of the process as it applies to the major federal agencies, see Gerald E. Galloway, Jr., Impediments in the Process for Development of Federal Water Resources Projects: Why All the Delay and What Can We Do About It? (prepared for the U.S. Water Resources Council, September 1981).

The Feasibility Report. At full cost to the federal government and at the request of a local sponsor (state or local government), field offices of the federal water agencies undertake a feasibility study to examine a potential water project from engineering, environmental, and benefit/cost perspectives. If the evaluation suggests a feasible engineering solution, without objectionable environmental problems, that will yield benefits in excess of costs, the project is presented to the Congress for construction authorization.[9] During this process, coordination with state and local officials is encouraged, but the federal agencies solicit relatively little direct input. A project's benefit/cost ratio is calculated at this stage.

Project Authorization. The Congress examines all this information, and if, in its judgment, the project has been evaluated fairly and appears to be in the national interest, it becomes one of a number of such projects contained in a water project authorization bill. Historically, there has been such a bill about every two years since the turn of the century, although the last authorization act was passed in 1976. A benefit/cost ratio of less than one will prevent a project from proceeding to the authorization step. But critics of this process insist that a B/C greater than one is not difficult to show because of the uncertainty inherent in procedures used to calculate project benefits.

Project Appropriation. It is relatively easy to authorize a water project because no funds are committed to its construction until the third major step--project appropriations. Each year, the federal water agencies submit their budgets for Congressional approval, including the agency's recommended spending on water projects. The pivotal decisions on federal spending are made at this stage. Based on OMB and agency recommendations, certain projects are selected for funding each year while others are not. Many more projects are authorized than the number chosen for yearly appropriations, creating a backlog of authorized but unfunded projects. In fiscal year 1982, for example, no request for appropriations was made for over 250 authorized, ongoing Corps projects. Another 362 authorized Corps projects had been deferred or were considered inactive. Once a potential project has progressed to the appropriations stage, economic selection criteria become much less important in guiding the choice of projects. Funding decisions generally follow highly charged Congressional debate.

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9. The Office of Management and Budget is responsible for screening project feasibility reports prior to authorization. All Congressional action is at the committee level until an authorization or appropriations bill is presented to the entire Congress. Different committees handle the affairs of different federal water agencies.

CHAPTER III. SHIFTING WATER DEVELOPMENT PRIORITIES

Over the last 150 years, the federal role in water project decisionmaking and financing has evolved primarily out of a concern for the objectives of an expanding industrial and agricultural economy. These objectives have included: stimulating regional economic growth (inland navigation, irrigation, hydropower); providing for the national defense (ports and harbors); and creating aesthetic or nonmarketable benefits (flood control, water quality, fish and wildlife preservation). To be sure, these are still valid objectives for federal investment in some new water projects. But most of the federally important water projects are now in place, to a large degree satisfying the economic development objectives that have guided past policies. As a result, emerging water development priorities are shifting away from large interstate projects toward local development, rehabilitation, and efficient management of existing water projects. This trend suggests a much stronger role for economic efficiency as a guiding principle in public investments.

SHIFTS IN FEDERAL SPENDING

The days of huge federal outlays for equally large water projects appear to be over. In real terms, appropriations for water project construction under the four federal water agencies have declined by almost 80 percent over the last 16 years, from about $6 billion in fiscal year 1968 to $1.3 billion in fiscal year 1984 (see Figure 1). Major river basins--the Ohio, Mississippi, Missouri, and Colorado, to name only a few--have been improved to provide flood control, navigation, and hydropower.

By contrast, federal spending for operation, maintenance, and rehabilitation (OM&R) of existing facilities has increased. Since 1968, the combined OM&R appropriations for the Corps, the Bureau, and the TVA have increased by 38 percent in real terms. As a percentage of new construction appropriations, OM&R appropriations have increased from 23 percent in 1968 to over 100 percent in 1984 (see Figure 2). For the first year in history, the Corps' budget request for operation and maintenance for fiscal year 1984 is larger than its budget request for construction.

Figure 1.

Combined Appropriations for Water Project Construction by the Corps of Engineers, Bureau of Reclamation, Soil Conservation Service, and Tennessee Valley Authority

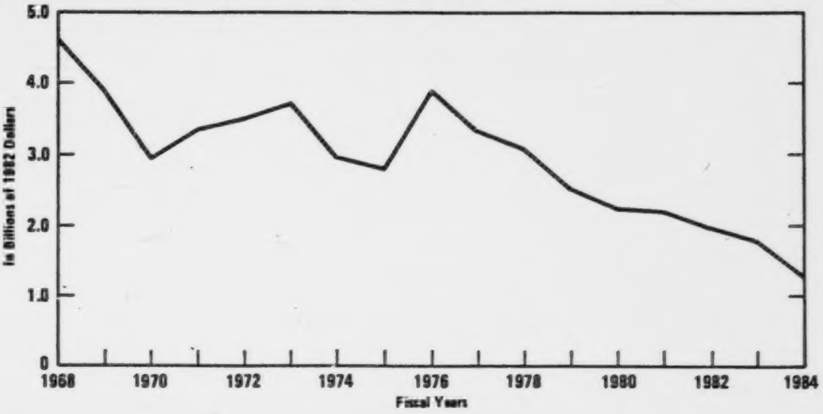
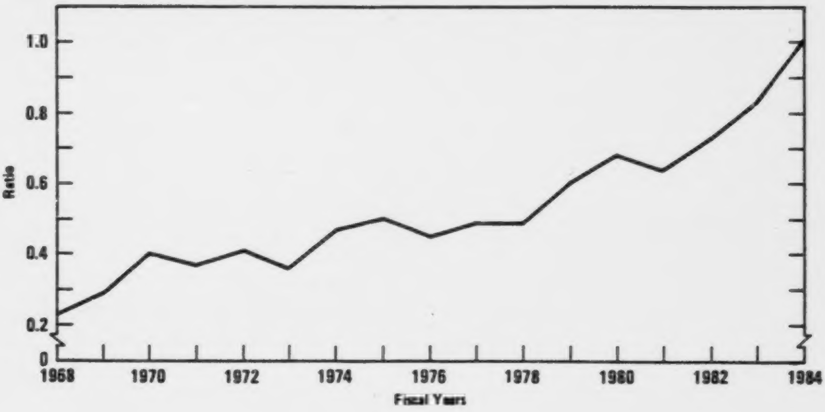


Figure 2.

Ratio of Combined Operation, Maintenance, and Rehabilitation Appropriations to New Construction Appropriations of the Corps of Engineers, Bureau of Reclamation, and Tennessee Valley Authority



REALIZATION OF ECONOMIC DEVELOPMENT GOALS

The principal federal water resources programs were authorized in the early part of this century in response to emerging national development needs. But over the last half century, many of the development goals have changed markedly. One of the best examples is the irrigation program administered by the Bureau of Reclamation. Conceived at the turn of the century, the Bureau's mission was to help settle the West by subsidizing the construction of irrigation works and thus the price of irrigation water for family farmers. For the average federal dollar invested in building irrigation projects, all nonfederal interests combined invest only 11 cents. Today, western agriculture is a mature industry, due in part to 80 years of building subsidized irrigation projects. Western lands have indeed been settled over the past 80 years--in some areas, excessively so. Under water resource constraints, some western states, notably Arizona and California, are actively exploring ways to transfer agricultural water rights to more valued uses (primarily municipal drinking water).

Navigation projects provide yet another example of goals that have changed. The mission of the Corps of Engineers in 1826 involved developing the nation's waterways to provide a link for commerce between older U.S. cities (the major domestic centers of consumption) and the developing agricultural and industrial regions of the Midwest. As agriculture and industry moved west, development of inland waterways followed. Today, most agricultural and industrial regions are served by inland waterways, railroads, interstate highways, and oil and gas pipelines. But the federal government still pays for 94 percent of all lock and dam construction, dredging, and operation costs associated with maintaining the waterways. The historical policy basis for a subsidized system of waterways has been eroded by the development of highly competitive alternative means of transport. The problem is no longer one of developing the only practicable means of transporting goods but of maintaining the most efficient transportation network to serve the needs of the entire nation. 1/

SHIFTS TOWARD LOCAL PROJECTS

In part, federal interest in developing the nation's water resources grew out of a need to facilitate interstate commerce with a system of

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1. National Water Commission, New Directions in U.S. Water Policy, Final Report, Summary, Conclusions, and Recommendations (June 28, 1973).

inland waterways and ports and harbors. Today, these facilities are in place to the extent that they are economically justified relative to other competing modes of interstate transport. Future navigation needs will be primarily rehabilitation and maintenance of existing works. 2/ Federal activities in flood control, irrigation, and hydropower originated as single-purpose solutions to localized water development needs. But in the 1930s, with the advent of the river basin planning concept, these and other federal water development proposals were combined into major multipurpose interstate projects. Like the development of any natural resource, the most favorable sites were developed first. For example, under the TVA, the Tennessee River Basin's interstate water resources potential has largely been developed over the past 50 years. Similarly, a series of five large multipurpose reservoirs on the Missouri River mainstem already provide interstate flood control, irrigation, navigation, and other benefits to nine states.

Most analysts would now agree that the majority of large multipurpose projects that appear capable of meeting economic and environmental standards have already been built. For example, out of ten new projects recommended for funding in 1983 by the Bureau of Reclamation, four were for rehabilitation and maintenance of existing irrigation systems, four were for local irrigation construction, and two were for upgrading hydroelectric facilities at existing dams. Of nine projects proposed by the Corps of Engineers as new starts in 1983, four were local flood control projects designed to protect urban areas and three were hydroelectric projects with 100 percent local financing. In the Water Resources Council's first assessment of the nation's water resources in 1968, it was estimated that annual nationwide flood losses would total about $5 billion by 2020, and that three-fifths of these losses would occur in small upstream communities. Protecting these communities involves local flood control measures. Many downstream communities were considered protected by major flood control dams already constructed by the Corps of Engineers.

GROWTH IN STATE AND LOCAL CAPABILITIES

Many federal water development programs were conceived at a time when state and local governments were considerably less sophisticated than they are today. At the time that these programs were conceived, primarily over the three decades between 1930 and 1960, state and local government

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2. See U.S. Army Corps of Engineers, Institute for Water Resources, National Waterways Study--A Framework For Decisionmaking--A Summary (January 1983).

staffs were smaller in number, less well-trained in technical areas, and generally less able to manage complex water resource development projects. In addition, there was less interstate communication and a much lower level of state spending for water resources than there is currently. Between 1960 and 1980, the number of state and local water resources employees increased from about 70,000 to about 115,000, or a 64 percent increase, while the number of federal employees has remained constant. State and local general expenditures for all water resources purposes increased from $89 per capita ($16 billion total) in fiscal year 1960 to $111 per capita ($25 billion total) in 1980 (in 1982 dollars). 3/ The number of interstate water planning and management organizations more than doubled since 1960. 4/

State and local capabilities to finance water resources development have also matured considerably over the past 20 years. State bonding activity has increased seven-fold since 1959. In the state of New Jersey alone, over $1 billion in water resources bonds have been issued since 1969. Over the three-year period 1980-1982, the fifty states combined issued almost $8 billion in water resources general obligation and revenue bonds. 5/

In response to the continuing decline in federally funded water development, many states have created new state water development programs or have stepped up ongoing programs. In Florida, recently created Water Management Districts are authorized to levy ad valorem taxes in order to finance local water projects. They also have created local water supply capital funds from a recently imposed real estate transfer tax. Newly created demand for water resources services will be financed by incoming residents under this program. In Montana, a water development

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3. Calculated from unpublished data provided by the U.S. Bureau of the Census. Partial information may be obtained from two of their annual publications, Government Finances and Public Employment.

4. The proliferation of interstate organizations resulted in part from the Water Resources Planning Act of 1965 and activities funded through the U.S. Water Resources Council, created by that act. In 1982, when most of the activities of this agency and its staff were eliminated, funding for many interstate water planning agencies was abolished. While some interstate groups have reorganized to continue their work, the future of others is in question.

5. For additional details, see U.S. Congressional Budget Office, Current Cost-Sharing and Financing Policies for Federal and State Water Resources Development (July 1983).

fund was created in 1981 to make loans and grants to individuals and substate groups for all water development purposes. The fund is financed from mineral royalties and a portion of the state coal-severance tax. In Pennsylvania, $300 million in general obligation bonds were sold in 1982 to make public water supply loans to local jurisdictions from a special public water supply loan fund. These are only a few examples of the states' growing financial capabilities. In all, 32 states now bond at the state level for water development; 26 states dedicate portions of some state taxes or collect user fees to finance water resources development; 33 states have water development loan and grant programs; and 29 states have established some form of special fund to support new water development.

CHAPTER IV. ECONOMIC EFFICIENCY AND WATER RESOURCES INVESTMENTS

Throughout the history of federal water resources development, efficiency of public investment has been recognized as one basic objective. It has not been the only objective, however, and rarely has it been the dominant concern. Water projects have been undertaken for economic, social, military, or political purposes. When these latter objectives guide investment decisions, often the result is a smaller net economic gain than otherwise would be available. Inefficient public investments cause national income to be smaller than it would be if conditions of maximum economic efficiency were to prevail. 1/ To the extent that economic efficiency becomes a major objective of water resource investment, the methods by which water projects are evaluated, financed, and ultimately paid for would require reexamination.

This chapter begins by defining economic efficiency as it applies to water projects. It then sets out guidelines for rethinking project selection, cost sharing, and financing policies directed at greater public investment efficiency. Chapter V identifies alternative water resource policies that could lead to greater efficiency and assesses their advantages and disadvantages.

ECONOMIC EFFICIENCY

Definition

Economic efficiency is an objective of investment decisionmaking that can be used to select among alternative water project designs (or indeed, between building a project or not). A water project is considered efficient if the dollar value of benefits to the economy flowing from the project is

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1. For a thorough treatment of economic efficiency and water resources development, see John V. Krutilla and Otto Eckstein, Multiple Purpose River Development, (Baltimore, Md.: Johns Hopkins Press, 1958, published for Resources for the Future).

greater than the dollar value of goods forgone by individuals in order to construct and operate the project. Thus, when a water resources investment is guided by economic efficiency, the result is increased total national income. A water project's relative efficiency can be enhanced by altering its size, composition, or timing so that project benefits increase without incurring additional costs.

One way to evaluate a water project's "benefits to the economy" is to add all users' willingness to pay for the marketable benefits to some other measure of the value of the nonmarketable benefits. In an irrigation project, for example, a farmer should be willing to pay for irrigation water so long as his increase in income from irrigating is greater than his increase in production costs resulting from irrigation (including the added costs for water delivery, distribution, and irrigation equipment). Evaluation of nonmarketable benefits is sometimes more difficult. Individuals (or public entities) may not be willing to pay very much for public goods available to others even though by some other measure, these benefits are worth more to "society" collectively than they cost to produce. Flood control benefits, for example, can be evaluated on the basis of damages prevented even though private parties may not be willing to pay for protection.[2]

In this paper, changes in cost-sharing conventions and administrative processes are aimed at distinguishing efficient water projects (or levels of development of a given project) from inefficient projects. Assessing the relative efficiencies of competing projects can also help decisionmakers choose those projects with the greatest returns to the national economy, subject to fulfilling other policy goals. It is the former objective--simply distinguishing efficient projects from inefficient ones--that is of primary concern here. The latter objective--choosing among efficient projects--is important for proper resource allocation, but may have undesirable distributive effects among regions or may conflict with the pursuit of other social or political goals. Nonetheless, choosing among efficient projects is an appropriate longer-term goal of water policy reform.

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2. Market imperfections are discussed in more detail elsewhere in this paper. For a more complete discussion of economic efficiency in water resources development, see Arthur Maass, et al., Design of Water Resource Systems (Cambridge, MA: Harvard University Press, 1962); and Otto Eckstein, Water-Resource Development, The Economics of Project Evaluation (Harvard University Press, 1958).

Efficiency and Market Imperfections

The efficiency of committing scarce resources to the production of water resources benefits could be evaluated easily if all these benefits were derived through a market at prices determined by supply and demand interactions. This is seldom the case, however. For example, there is no ready market for selling flood protection. A system of levees providing flood protection to one member of the community will provide protection to the entire community. Thus, any member could choose not to pay on the chance that the contribution of others would be sufficient, which in turn would make other members reluctant to pay because their share could increase accordingly. Protection cannot be denied an individual who refuses to pay without simultaneously denying protection to all those who are willing to pay. This "free rider" problem can lead to underinvestment in public goods like flood control. Private enterprise, for example, would be unwilling to build flood control structures in the absence of firm contracts to guarantee payment, even though the cost of building flood control works could be far less than the collective community flood damages they would prevent. Conventional markets, therefore, are inadequate to ensure efficient resource allocation to flood control.3/

This implies a role for public entities in the provision of nonmarketable water resources benefits. But public provision of water resources benefits does not necessarily mean that economic efficiency must be sacrificed. Beneficiaries' willingness to pay for nonmarketable benefits can be approximated (as if a market existed) and the costs of providing them can be identified. For example, flood prevention benefits would equal the aggregate cost of repairing flood damages and avoiding the inconveniences associated with flooding.4/ Flood control costs are calculated like any

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3. Similar arguments describe market failures for other water resources benefits, including water quality, fish and wildlife maintenance, instream flow maintenance, and others. For additional detail, see Krutilla and Eckstein, Multiple Purpose River Development.

4. More precisely, benefits include the cost of restoring private and public land and structures to preflood conditions; loss of net farm revenue due to inundation; commercial losses; indirect losses, such as cessation of production, loss of wages and other income; and the cost of evacuation, emergency work, or flood relief. In practice, these benefits are calculated by subtracting annual flood losses with the project from those without the project. Since the incidence of flooding is probabilistic, benefits represent average annual changes in

other water resources investment--the value of land, labor, and materials committed to construction, operation, and maintenance of the project.

Therefore, while market imperfections do exist in the provision of many water resources benefits, economic efficiency can still help guide these investments. Like marketable benefits, such as hydroelectric power or municipal water supply, the application of an efficiency criterion to the provision of nonmarketable benefits has certain implications for cost-sharing and administrative processes.

ECONOMIC EFFICIENCY AND COST-SHARING POLICY

There are three parties to cost-sharing arrangements for water resource investments: the federal government, state and local governments, and private beneficiaries. The economic issue is whether a different division of cost than now exists would lead to greater efficiency. There is much evidence to suggest that efficiency would be improved if the federal government bore a lower share of the cost than it does under current policy.

The Basis for Federal Sharing of Water Development Costs

The federal government bears a portion of the cost of water projects for two reasons. First, in order to stimulate economic development or induce certain economic activities, the federal government has assumed a large part of the cost that direct users would otherwise pay. Examples include the federal subsidy intentionally built into irrigation or navigation cost-sharing policies. Perhaps less intentional subsidies characterize federal policy for hydroelectric power and municipal and industrial water supply projects.

Second, the federal government has traditionally provided nonmarketable, water-related benefits that the private market would not otherwise provide. The interstate nature of past water projects--multireservoir flood control systems, for example--is one reason why these costs have been borne primarily by the federal government as opposed to state or local govern-

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4. Continued
losses, assuming constant flood probablities and a reliable relationship between flood intensity and damages incurred. For additional details, see Otto Eckstein, Water Resource Development--The Economics of Project Evaluation.

ments. 5/ In addition, until relatively recently, state and local governments were not well-equipped technically or financially to undertake complex capital-intensive water development projects. Federal provision of flood control projects originated in the 1860s after a series of devastating floods in the lower Mississippi Valley. Local protection efforts were ineffective and the multistate protection plan envisioned by the Corps of Engineers was beyond the financial capability of the states. A national sense of urgency was, in large part, responsible for federal assumption of flood control costs.

How High Federal Cost Shares Promote Inefficiencies

A water development project often provides benefits directly to users (for example, water supply and hydroelectric power) or to the public in the general area of the project (such as prevention of flood damage to an entire river basin). When either group pays only a small portion of a water project's cost, the benefits they receive are, in effect, subsidized, thereby providing an incentive to demand more or larger projects than they might be willing to pay for if their own money was involved. This can cause public overinvestment and poor allocation of resources. Every public dollar invested in a questionable water project is a dollar that cannot be invested in some other productive economic capacity. Federal projects for irrigation and navigation, for which users do not bear their proportion of the costs, provide two examples.

Irrigation. Western farmers pay an average of only 19 percent of the cost of providing federally developed irrigation water, resulting from a 1902 federal policy to subsidize western settlement. The intent of the 1902 Reclamation Act was to stimulate small, private farming (160 acres or less per farm) within the largely unsettled western states by allowing repayment of federal construction costs, without interest and over a ten-year period. Repayment and acreage terms have become more liberal while real interest

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5. Water projects with interstate implications may justify federal coordination but not necessarily federal assumption of costs. In the case of interstate spillovers, some federal funding can be effective to induce states to build the "socially optimal" project size rather than, perhaps, a smaller project that would benefit only a single state. This argument, however, seems more persuasive in the case of water quality control, in which the federal government provides a large portion of sewage treatment plant capital costs to induce a higher level of pollution control than localities acting on their own behalf might wish to pay for.

rates have risen over the years, maintaining a subsidy to western agricultural interests and resulting in inefficient public investment.[6]

Long after the policy goals of the 1902 Act were achieved (the West is largely developed to the extent dictated by resource constraints), federal subsidies have led to the construction of irrigation projects long before they may be needed, and to the reclamation of lands at per acre costs far in excess of the value of the land after the project is completed.[7] Because farmers pay such a small share of the real cost of irrigation water, they actively promote more and larger projects than they otherwise would. Federal subsidies for irrigation charge general taxpayers for building projects that small groups of beneficiaries would be unwilling to pay for, if they were assessed their full cost. Furthermore, high federal cost shares, resulting in artifically inexpensive irrigation water, provide farmers with little incentive for efficient use of that resource and allow the cultivation of water-intensive crops that would not be grown if water was priced at the cost of providing it.

Navigation. In the early 1800s, the Congress directed the Corps of Engineers to construct inland waterways and ports and harbors to serve emerging agricultural and industrial development in the South and West. Inland waterways were seen as the only means of transportation to link these regions to cities in the East. As development moved westward, so did federal construction of inland waterways. Federal port and harbor development was originally undertaken to facilitate overseas trade and to provide for the national defense. Today, the federal government pays 94 percent of the construction and operation costs of inland waterways and 84 percent of the cost of ports and harbors.[8]

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6. In 1939, The Reclamation Projects Act introduced the concept of "ability to pay," allowing farmers to repay a much smaller portion of construction costs over a 40-year period based on increased farm income resulting from the project. In 1982, the acreage limitation was liberalized to allow subsidies to farmers irrigating up to 960 acres.

7. See National Water Commission, New Directions in U.S. Water Policy, Summary, Conclusions, and Recommendations (1973), p. 168.

8. State and local government contribute necessary lands, easements, and rights-of-way which account for about 6 percent of the costs of inland navigation projects and 16 percent of ports and harbors. In addition, a small fuel tax is collected from users of inland waterways. For example, in 1981 the 6 cent per gallon tax raised $40 million in revenues, or about 6 percent of the 1981 combined federal capital and operating outlays for the inland waterways.

Times have changed, however, and facilitating regional development by providing subsidized waterways may no longer be in the national interest. What is in the national interest is ensuring the most cost-effective transportation system to serve the needs of the entire country. In 1980, federal subsidies covered more than one-fourth of the costs of all inland waterway shipping. This is more than four times the portion of shipping costs covered by rail subsidies and almost 30 times more than truck subsidies. 9/ Oil and gas pipelines, which compete directly with inland barges, receive no federal capital or operating subsidies. Thus, a federal cost-sharing policy providing subsidies encourages waterway investments that may not be cost-effective. 10/ Such a policy also diverts some traffic from railroads or trucks to waterways, because of lower, subsidized transportation costs which transfer proportionately more of the cost of freight from direct users to general taxpayers.

State and local governments may face a similar incentive for overconsumption if the benefits their jurisdictions enjoy are provided by the federal government at a subsidized rate. Availability of federal funds with low cost-sharing requirements from state or local governments can lead to federal construction of projects yielding primarily local benefits. When the cost of a local project is shifted from local beneficiaries to federal taxpayers, scarce federal resources are allocated to support local economic activity, displacing investments in other projects which may have a higher

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9. For additional details, see U.S. Congressional Budget Office, "Statement of Alice M. Rivlin, Director, before the Committee on the Budget of the U. S. Senate" (March 10, 1982), pp. 7-8.

10. Probably the best example of this is the Tennessee-Tombigbee waterway construction project. The project was originally evaluated in the 1940s and authorized by the Congress for construction by the Corps of Engineers in 1946 based on favorable economics perceived at that time. Because the project would bring economic opportunities to the region, at a very low local cost, local proponents successfully defended the project against formidable opposition until construction finally began in 1971. Based on the most recent calculations made by the Corps (1976), the project will yield $1.08 in navigation and other benefits for every $1.00 invested. In a 1981 review of the project, the General Accounting Office concluded that some 30 to 40 percent of the expected benefits will never materialize. If local proponents had been faced with paying the entire project cost, not 6 percent as under current policy, it is highly unlikely that they would have supported its construction at all. Competing rail or existing waterway routes would have provided a less expensive alternative.

national interest. Federal projects for flood control or municipal water supply provide two examples.

Flood Control. The federal government started to invest in flood control structures in the mid- to late-1800s as settlements in the lower Mississippi Valley began to experience devastating floods. Cost sharing for these projects was eventually formalized in the Flood Control Act of 1936, following severe flooding throughout the nation. Local beneficiaries were required to contribute necessary land, easements, and rights-of-way, as well as to maintain and operate structures after completion. But after two years of frustrated efforts at local coordination and continued severe flooding, local cost-sharing requirements for reservoirs were eliminated. In this context--a feeling of urgency, recognition of local coordination obstacles, and pressure for New Deal jobs programs--the current 100 percent federal share of costs for major flood control works was established.[11]

Although complete self-financing may never be realistic, as long as flood control projects are essentially free goods, communities will have an incentive to overstate their needs to influence the decisionmaking process and thereby receive projects. Moreover, local proponents will try to show that the benefits of flood control projects are larger rather than smaller in order to generate acceptable benefit/cost ratios.[12] If the costs of flood control projects exceeds the development value of flood-free land, investments in such projects would be inefficient. Local proponents would have less motivation to overstate benefits if they were responsible for paying a larger share of a project's costs.

Experience has shown that recovery of flood control costs directly from beneficiaries is not feasible. Efficiency could be served, however, if local jurisdictions, acting collectively for their protected citizens, paid a higher proportion of the costs of federal flood control projects, perhaps by imposing an assessment on lands benefitting from flood control investments. A higher local share would help ensure state and local support for the most cost-effective flood control projects.

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11. Local participants in federal flood control projects classified as "local protection" are still required to contribute necessary land easements and rights-of-way that can range up to 20 percent of project capital costs. On average, for all Corps urban flood control projects, local participants pay 17 percent of total project costs. Local participants pay 7 percent on average of rural flood control project costs.

12. Otto Eckstein, Water Resource Development (1958), p. 154.

Municipal Water Supply. Under the Water Supply Act of 1958, the Corps and the Bureau may include municipal and industrial (M&I) water supply in multipurpose reservoirs, provided that they obtain reasonable assurance that such supplies are needed and will be paid for by local users within the life of the project. But under current Corps' cost-sharing conventions, if the water is never used, no repayment is required. Further, while federally developed M&I water lies unused waiting for demand to develop, the interest portion of construction costs plus all operation and maintenance allocated to the M&I purpose are paid by the federal government. The effect of this subsidy is to reduce the nominal nonfederal cost share of 100 percent for M&I water supply to an effective nonfederal share of only 64 percent. The Corps and the Bureau estimated in 1980 that together they have spent or will spend about $1.3 billion for authorized M&I supply. Even if all supplies eventually are used, the nonfederal share will repay only $800 million of that investment, based on the historic effective nonfederal share for M&I supply. 13/ Further, in a 1978 survey of seven Bureau reservoirs that had reserved industrial water supplies, 96 percent of the reserved supply was not used by potential industrial customers--only four percent of the total supply available was delivered, and the Bureau did not expect to deliver more than that in the near future. 14/

The original intent of the 1958 act was to provide M&I water in the most efficient manner; the economies of scale in many large federal multipurpose developments allow the development of M&I water at a lower cost than could otherwise be achieved. To make this water available to municipalities and to industry at cost would be both efficient and in the national interest. But to provide this commodity at federally subsidized prices transfers the cost from direct beneficiaries to the general taxpayer. Furthermore, low prices promote wasteful use of water once it is delivered. Unused M&I water ties up scarce federal resources, preventing their commitment toward productive economic activity in other uses.

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13. For additional details regarding the Corps' and Bureau's role in providing municipal and industrial water, see U.S. General Accounting Office, Contracts to Provide Space in Federal Reservoirs for Future Water Supplies Should be More Flexible (May 16, 1980).

14. See U.S. General Accounting Office, Water Supply Should Not Be An Obstacle to Meeting Energy Development Goals (January 24, 1980).

Efficiency-Motivated Changes to Current Cost-Sharing Policy

With the above examples in mind, changes in current cost-sharing policies can be formalized, based upon marketability of project benefits. First, marketable water project benefits would be separated from those that are nonmarketable. Second, regardless of who finances a water project (a separate question from who pays, which is addressed in the next chapter), systems of user fees would be devised to recoup the cost of providing marketable benefits from direct beneficiaries or small groups of users. Finally, the cost of providing nonmarketable benefits would be shared between the federal government and state and local governments when applicable. In order to accomplish the above steps, two sets of criteria are needed: one that separates marketable from nonmarketable benefits, and a second that allocates nonmarketable benefits among the appropriate public entities.

Marketability of Benefits. All water project benefits can be classified as marketable or nonmarketable based on three factors: how benefits are supplied to users or beneficiaries, the cost of marketing, and the ability to distinguish between direct users and the general public. Marketable benefits include municipal, industrial, and agricultural water supply; inland navigation; harbor improvement; hydroelectric power; recreation; erosion control; and drainage. Nonmarketable benefits include fish and wildlife enhancement, water quality, flood control, area redevelopment, and preservation of historic sites and natural or ecological systems. 15/

Hydroelectric power and municipal, agricultural, and industrial water supplies are easily marketed benefits that may be supplied on a unit basis and priced at market or cost-of-service rates for readily identifiable groups of users. Both water and electricity may be purchased in discrete units (gallons or kilowatt-hours, respectively). Marketing costs are generally low and users are easily singled out from nonusers. Most recreation, inland navigation, and harbor improvement benefits are also marketable through a

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15. Apportioning all water resources benefits into two categories is, perhaps, simplistic considering the diversity of benefits and the criteria that determine marketability. For an interesting discourse on the marketablility of water benefits based on public market failure, see David J. Allee, "Failure of the Public Market--a Framework for Cost Sharing Policy Research," in Ronald M. North and Steven H. Hanke, eds., Financing Water Resources: Cost Allocation, Cost Sharing, Incentives (The University of Georgia, June 1982).

system of user fees to recover allocated costs. [16] Although these benefits may not be purchased one unit at a time, they may be valued and priced according to use by an easily separated group of users. Inland navigation benefits are probably more efficiently marketed at the federal level because the inland waterway system operates as an interstate transportation network. Systems to recoup the cost of providing these benefits could incur limited administrative costs, but revenue collected would far exceed any overhead.

Erosion control and drainage benefits are considered slightly less marketable because they cannot be delivered on a unit supply basis and cost-recovery systems may be slightly more complex. [17] Nevertheless, users are still identifiable and costs can be recovered relatively inexpensively through imposition of a value added tax, for example. Some types of erosion control benefits and all drainage benefits may be priced according to relative productivity gains, or at the value of beneficiaries' economic output with the project versus output without the project.

Another group of benefits--fish and wildlife enhancement, water quality, flood control, area redevelopment, and preservation of historic or cultural sites--are not easily marketed because administrative costs are high or market imperfections prevent isolation of beneficiaries. Partial recovery of fish and wildlife benefits may be possible through sales of hunting and fishing licenses, but revenues could sometimes fall short of administrative costs. Real estate tax assessments could recover some costs of urban and rural flood damage reduction, but valuation is difficult and

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16. There is no consensus on the correct way to separate navigation costs from total multipurpose project costs. The Corps of Engineers has devised a number of procedures that are applicable in different situations. Thus, while navigation benefits are marketable, some controversy surrounds separating these benefits from overall project benefits.

17. Erosion control and drainage projects transform previously unusable land into tillable acreage. For example, a drainage project entails construction of channels to drain a swamp and keep this low-lying area drained and usable for production. One type of erosion control project prevents loss of soil from agricultural land, thus allowing cultivation. Erosion control also is used to prevent beach erosion, which may not be marketable.

administrative costs might be high. 18/ Area redevelopment and preservation of historic site benefits might be vendible to concerned groups or associations, but no precedent for such a sale exists and legal or economic problems could arise.

Finally, current or future public goods are considered nonvendible. Such goods include stream flow regulation for aesthetic or ecological reasons, management of nonpoint source water quality (usually land management or forestry), and maintenance of natural areas and ecological systems. When these benefits are provided, the public in general is the beneficiary, not individuals or groups of users. Further, consumption of these benefits does not diminish future availability for other beneficiaries.

Sharing the Costs of Nonmarketable Benefits. Economic principles are perhaps less helpful in allocating the costs of public goods or other nonvendible benefits among the different levels of government. But there are practical considerations that might guide such a policy, including providing incentives to prevent under- and over-consumption, or ensuring equitable treatment of the fiscal capacities of state and local governments relative to each other and to the federal government. If the federal government paid all the costs of nonmarketable benefits, states would have an incentive to demand more water projects than if they had to pay a portion of each one. If the states paid all nonmarketable costs, some worthwhile projects might not be built. Either arrangement would imply that all nonmarketable benefits accrue to only one level of government. Sharing costs would help prevent under- and over-consumption while recognizing that all public entities have a stake in providing public goods.

In addition, not all states are equally able to afford such payments. In relation to federal fiscal capacity, individual states may be at a disadvantage. A marginally larger federal share in financing nonmarketable costs recognizes a stronger federal fiscal capacity--greater creditworthiness, lower interest rates on debt, greater ability to shift funding priorities, and the like. As the economic burden on states is reduced, state-to-state fiscal inequity becomes less important.

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18. For example, flood control districts in Wisconsin are authorized to levy flood damage reduction user fees to recover the cost of building and maintaining flood control works. So far, only one district has attempted to use its authority, and when beneficiaries were informed of the user fees they would have to pay, the project lost local support.

ECONOMIC EFFICIENCY AND ADMINISTRATIVE PROCESSES

Aside from the inefficiencies promoted by current cost-sharing conventions, the administrative processes by which water projects are evaluated, authorized, and funded are long and complex, often resulting in project delays as long as 28 years. 19/ Delays tie up productive resources for long periods, leaving water resources needs unmet in the field. In addition, the information used to select water projects is often not sufficient to ensure the economic viability of water projects once they are built. Local decisionmaking over water resources investments that yield mostly local benefits could reduce development delays and improve the project selection process. State and local input during benefit and cost evaluation, coupled with a priori knowledge that local benefits will be provided by local sources of funding, might yield more realistic assessments of overall project feasibility.

The Authorization and Appropriation Process

The process by which water development needs turn into public works in operation is quite long--up to 28 years, and at any step along the way, a project may be delayed or cancelled. 20/ For the smaller, more localized projects that are likely to dominate future water resources development, the current process can cause needless delays while water problems persist.

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19. See Gerald E. Galloway, Jr., Impediments in the Process for Development of Federal Water Resources Projects: Why All the Delay and What Can We Do About It? (prepared for the U.S. Water Resources Council, September 1981).

20. For 24 Bureau of Reclamation projects, the average time elapsed between the initial study and project operation is 28 years. For Corps of Engineers projects, average time between study authorization and project completion is about 26 years. SCS projects move considerably faster; they are generally completed within 15 years of initial study. For a detailed discussion of this issue, see Galloway, Impediments in the Process.

Since all the water agencies are similar in this respect, only the Corps of Engineers' procedure will be highlighted as an example. 21/

Once a water resources problem is recognized and the Congress approves a feasibility study, it takes, on average, 4.4 years for the Corps to receive an appropriation to pay for the study. The study itself takes about 4 years to complete, during which time an Environmental Impact Study is prepared. Review by the Corps, Office of Management and Budget (OMB), and the Congress of the feasibility report takes another 1.5 years on average. If approved by all reviewers, authorizing legislation must be passed by the full Congress and signed by the President. Once authorized, it takes an average of 11 years to obtain construction funding and design the final water project. Actual construction takes an average of 5.7 years, each of which requires another Corps' request for appropriations, approval by OMB, and appropriations by Congress.

Although this multistep process was designed to promote projects in the public interest and eliminate undesirable ones, more and more projects are simply being delayed, thus causing massive backlogs. For example, the Corps of Engineers has a backlog of over 400 authorized and active projects at various points in the process, which in aggregate would require about $36 billion to complete. Similarly, the Bureau has an authorized project backlog that would require $14 billion to complete. 22/

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21. Bureau and Corps projects are budgeted on a line-item basis while the SCS plans and builds projects from a general appropriation. Under a separate process, the Corps can build small water projects (up to $2 million depending on project type) without individual Congressional or Executive approval.

22. In a recent study, the General Accounting Office (GAO) estimated that the Corps and the Bureau had 934 authorized water projects needing about $60 billion to complete construction. Of these, 289 were funded in 1982; 257 were considered active, but did not receive funding in fiscal year 1982; and 388 were considered deferred or inactive. In order to complete the 289 projects actually funded in 1982, appropriations of $35 billion would be necessary in future years. The remaining 645 projects would require about $25 billion in future funding, although the GAO considered such funding to be uncertain. For additional information, see U.S. General Accounting Office, Water Project Construction Backlog--A Serious Problem With No Easy Solution (January 26, 1983).

While projects sit in line waiting for federal authorization or appropriations, water resources problems persist and the costs of meeting water needs can escalate with inflation. Further, while waiting for appropriations, the terms under which some projects were economically justified and authorized by the Congress can change considerably. For 46 active Corps projects and 17 active Bureau projects that were up to 25 percent complete in 1982, the average interest rate used to calculate costs and future benefits (when these projects were studied in the 1960s and 1970s) was 3.9 percent, compared to an interest rate around 9 percent that might conservatively be used for the same calculations today. Because total water project costs are dominated by capital-intensive construction costs in the early years and only yield benefits slowly over a 50-year project life, increasing real interest rates can put budgetary pressure on the federal government, the prime water project financier, and return eroded benefits over a very long period of time.

Screening Projects for Economic Efficiency

The Congress is responsible for authorizing feasibility studies, authorizing project construction, and appropriating funds annually for these two purposes. The benefit/cost ratio (B/C), developed during the feasibility study, serves as the economic screening process for the Congress, separating economically desirable projects from undesirable ones. As long as benefits exceed costs (a ratio greater than one), the Congress should find no economic reason to reject the project. But despite elaborate procedures to calculate benefits and costs, the science is inherently imprecise, so that projects reach the Congress for funding with an economic stamp of approval--a B/C greater than one--and yet with a highly imprecise evaluation of their economic merits. A second economic screening device--the willingness to pay of the beneficiaries--would provide better information to help guide the Congress in making water project investment decisions. 23/

Benefit/cost analyses are generally performed by field offices of the federal water agencies, the same offices responsible for constructing and sometimes operating and maintaining water projects. These agencies operate under a proconstruction mandate from the Congress that has slowly

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23. "Willingness to pay" encompasses more than just an expression of intent on the part of project beneficiaries. As used here, willingness to pay becomes operational when project beneficiaries either supply an up-front financing share of project costs or commit themselves to legally binding contracts for repayment of a share of project costs.

grown more powerful as the federal government has accepted a larger role in developing national resources. These agencies have become accustomed to building water projects, and their livelihood depends on continuing to do so. Therefore, it is in their best interests to describe project benefits generously and project costs frugally. Critics of this process claim that because of their vested interest in building water projects, federal water agencies do not produce impartial assessments of benefits and costs. [24]/

Because local sponsors have such a low financial stake in water projects, they have no incentive to make sure costs and benefits are calculated accurately. Their proportion of the cost of making a mistake is very low in relation to the benefits they will receive if the water project is built. The Congress, in effect, underwrites such activity by accepting the financial consequences of understated costs and overstated benefits; high federal cost shares transfer such liability from project beneficiaries to the federal government and, ultimately, to the general taxpayers.

Efficiency-Motivated Procedural Reform

Two types of procedural reforms are suggested by the administrative inefficiencies that exist under current policy. First, complex, centralized decisionmaking over essentially intrastate water project decisions suggests that state or local governments should become more involved with choosing projects that yield mostly local benefits. Second, the imprecision resulting from strict reliance on benefit/cost analysis as an economic screening process suggests increasing state or local participation during project evaluation and relying more on willingness to pay as a measure of project benefits.

Use of Local Information. To the degree that water development priorities continue to follow the recent trend toward smaller, more localized projects, the use of local information in making investment decisions will become increasingly more important. In addition, cost recovery for vendible benefits of intrastate projects could be implemented more effectively at the level of government closest to the resources--the states.

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24. Numerous studies have concluded that the federal water agencies consistently overestimate benefits and underestimate costs. Perhaps the most thorough treatment is found in Robert Haveman, Water Resources Investment in the Public Interest (Vanderbilt University Press, Nashville, Tenn.: 1965). See also U.S. General Accounting Office, An Overview of Benefit-Cost Analysis (1978).

Recently, many states have recognized the importance of setting their own water development priorities. In response to reduced federal financing and a conflict between their water development goals and federal policy, the western states have recently made it quite clear that they are interested in developing and managing their resources according to their own priorities. Since the so-called "Sagebrush Rebellion" in 1980, states have begun to advance this position more forcefully and have taken legal and financial steps to ensure continued development of western water. Evidence of this includes the 1980 Arizona groundwater law, the California State Water Project and Peripheral Canal proposal, and general proliferation of state water development funds throughout the western states. 25/

Eastern and midwestern states have also recognized the shortcomings of a completely centralized federal approach to water development, and have recently called for a comprehensive review of national water policies. 26/ They have identified serious management failures and inequities in the distribution of federal water funds. Between 1956 and 1980, the northeastern and north central states received only about 25 percent of all federal water resources outlays. The southern states received almost 40 percent while the western states received about 35 percent. 27/ Such

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25. For example, in 1980 the Arizona legislature passed a comprehensive groundwater management and use act implementing, among other things, wellhead pumping taxes, strict water conservation measures, and substantial fines for over-pumping—in return for final funding of the Central Arizona Project that would bring about 2.2 million acre-feet of lower Colorado River water to the Phoenix and Tucson metropolitan areas each year. California has spent about $2.5 billion over the last 20 years to capture spring runoff from the mountains north of Sacramento and to transport water through the California Aqueduct to water-short cities to the south. If constucted, the 43-mile Peripheral Canal would link the Sacramento River north of the San Francisco delta region to the South Bay Aqueduct to ensure continued supply to Southern California once the Central Arizona Project begins to divert Colorado River Water from California to Arizona.

26. See Northeast-Midwest Institute, Building A Water Policy Consensus: Key Issues for the Eighties, Washington, D.C. (June 1982).

27. Congressional Research Service, Environment and Natural Resources Division, unpublished data developed at the request of the staff of the Senate Committee on Environment and Public Works (March 1982).

an imbalance, claim eastern and midwestern officials, has resulted in the neglect of the water supply needs of older population centers while the growth-induced or special interest water needs of other regions have been addressed.

Willingness to Pay. Benefit and cost analysis provides aggregate information about overall project benefits and costs. Willingness to pay goes one step further by assigning the costs of a project to those who directly benefit from it. Under this second economic screen, users or beneficiaries would have an incentive to support only those projects whose expected return was greater than what they would pay to acquire it. To the extent such a screening process was used, project support because of federal subsidies would be reduced. Water projects would no longer be viewed as windfall opportunities but rather as investments. Decisionmaking at any level would be improved if this type of information was provided. Simply instituting cost-recovery mechanisms (user fees for vendible benefits or special property assessments for some nonmarketable benefits) would go a long way toward applying willingness to pay as a means of benefit estimation. If those who would be asked to pay for a project were integrally involved during project planning, decisionmakers would be more assured of a firm commitment to pay.

CHAPTER V. POLICY OPTIONS

Congressional concern for efficient water resources investments is beginning to focus on three areas for possible reform: project cost sharing, selection, and financing. In order to effect improvements through reallocated cost sharing, two principles stand out: first, users should pay the cost of providing marketable benefits in proportion to their use; and second, public entities should share the costs of providing nonmarketable benefits in rough proportion to the accrual of these benefits. With regard to project selection, a larger role for state and local governments in the decisionmaking process would recognize the shift from interstate to intrastate water resources projects and the potentially larger cost share that these government levels should bear. Apart from the issue of who ultimately pays for water projects (expressed in cost-sharing policy), the issues of who should finance these activities and how they should be financed are chief concerns of the Congress and the states. The forms of financing and the burden of "up-front" capital requirements on each partner could have profound effects on the way water resources are developed.

This chapter analyzes three policy alternatives representative of recent Congressional proposals:

- A federal loan program,
- Federal block grants, and
- Federal project grants under a limited federal role.

Each option would place greater responsibility for project selection, financing, and repayment on states and local governments and on direct beneficiaries. This emphasis could provide a greater incentive than current policy to ensure that the most cost-effective projects are built and maintained, and to guarantee an equitable distribution of government services. This shift in responsibility would also affect federal, state, and local budgets, and the costs borne by private-sector beneficiaries of water resources projects.

FEDERAL LOAN PROGRAM

A federal loan program would provide both the cost-sharing incentives to promote investment efficiency and a source of development capital for all states. Evaluation and selection of nationally important projects would remain at the federal level, while projects of local importance would be chosen by states according to their own priorities.

A federal loan fund would be established from which local investments could be financed. The fund would require federal appropriations initially, but over time it would become self-sustaining as states paid back their loans. The states would choose among development and maintenance priorities and request that fund monies be allocated to the appropriate federal water agencies to undertake projects specified by the states. Project benefits would be divided into two categories: marketable and nonmarketable. The states would assume legal responsibility for repaying the costs of providing all marketable benefits and an appropriate share (perhaps 50 percent) of the nonmarketable benefits. States would be given full legal authority to establish user fees or other cost-recovery mechanisms when necessary to meet their repayment obligations. The states would manage these projects once they became operational.

Loan requests would be submitted by the state governor to a federal water development loan board for review. The board would be composed of representatives from the Corps, the Bureau, the TVA, and the SCS; state representatives, perhaps from the National Governor's Association; and members at large selected by the Congress based on their demonstrated expertise in water development. Loans could be disbursed on a first-come-first-served basis.

Federal, state, and local personnel could conduct joint feasibility studies with an expanded scope. The states and the federal government would share study costs equally. These studies could include engineering feasibility, environmental impact analysis, market analysis for marketable benefits, and benefit/cost calculations for nonmarketable benefits. Feasibility reports would be submitted to the appropriate state governors' offices and to the director of the main federal agency involved in the project. They could serve as the basis for a loan application, stating the overall and annual construction costs, a schedule of repayments corresponding to annual sales of marketable products, a schedule of repayments corresponding to the state share of nonmarketable costs, and a statement of annual federal costs corresponding to the federal share of nonmarketable costs. Interest rates on the remaining loan balance could be re-evaluated every five years.

Separately, the federal government would form partnerships with appropriate groups of states to finance and manage interstate water resources systems (inland navigation or multireservoir flood control systems, for example). The federal government would finance new construction and operation of these projects, while the states would contribute any necessary land easements or rights-of-way. These systems would be managed by joint federal and state boards. The federal government would institute systemwide user fees when applicable to recover both construction and operation expenditures.

Economic Efficiency Under a Loan Program

A federal loan program could be a major step toward an efficient investment program for water resources. For both intrastate and interstate projects, beneficiaries would have to pay user fees to recover the cost of providing marketable benefits. The cost of providing nonmarketable benefits would be shared between the federal and state governments. If either user groups or the state judged the project to be uneconomic, the project would not go forward as planned. Either the project scope could be altered until benefits were perceived to be greater than costs or the project would be eliminated entirely, thus allowing the state and federal government to commit their resources elsewhere.

Because states would be financially responsible for repaying a much larger share of any project's cost than they now pay, those projects perceived by the state to have the highest net return on investment would be promoted first. The states would be responsible for repaying a minimum of 50 percent of any project's cost, even if all benefits were classified as nonmarketable. Compared to the current average nonfederal share of 30 percent, this represents almost a doubling of the financial responsibility of the states.

Moreover, the federal government would institute user fees to recover all costs associated with providing marketable benefits of interstate projects. Full-cost user fees would be established to recover the federal investment in new construction and annual operation and maintenance for inland waterway projects. To the extent that multistate flood control projects were still economically justified, they would be financed (and paid for) by the federal government. This arrangement, however, could continue to provide an incentive for states or beneficiaries of such projects to demand more or larger projects than they would if they were responsible for repayment.

Effects on the Federal Budget

In the early years of a loan fund, before state and user payments began to accrue, high loan demand could put budgetary pressure on the federal government. In time, however, state and user payments would actually reduce annual federal outlays for water projects. Federal outlays for construction of water projects totaled about $2 billion in fiscal year 1982; but this spending figure is low relative to a recent assessment of water resources needs.[1] To meet the federal financing responsibility for interstate projects plus the state loan demand, federal capital outlays for all water projects initially could increase to over $4 billion a year. If federal capital was substituted for the state capital that now finances strictly state water development, demand for federal funds could increase to over $6 billion a year initially. The repayments from user fees and the states, however, would reduce these demands over time.

It is difficult to assess the number or types of projects that would lose local support if user fees were instituted, but some projects would certainly be cancelled. One recent study of the effects of full-cost user fees on inland waterway traffic estimated about a 20 percent reduction in demand.[2] Similarly, a flood control project in Wisconsin was cancelled by local sponsors when citizens learned that real estate assessments would increase to pay for local flood protection. Bureau officials have concluded that demand for irrigation water would drop dramatically and some pending projects could be cancelled under a system of user fees to recover the full cost of service.[3] If overall demand dropped by 30 percent, federal outlays in the early years of a loan program could be held to about $3 billion a year.

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1. A recent Congressional Budget Office estimate of water resources needs based on federal water agencies' assessments included an additional annual capital requirement of $400 million for inland waterways, $60 million for ports, $700 million for dam safety, and about $600 million for backlogged but authorized projects. In aggregate, annual capital needs could increase from the 1982 level of $2 billion to about $4.1 billion. This level of outlays would have to be maintained for at least ten years. See Congressional Budget Office, Public Works Infrastructure: Policy Considerations for the 1980s (April 1983).

2. U.S. Department of Transportation, Inland Waterway User Taxes and Charges (February 1982).

3. For additional details, see U.S. Department of the Interior, Bureau of Reclamation, Preliminary Regulatory Impact Analysis for 43 CFR 426 Acreage Limitation (April 1983), p. 38.

Effects on States

On balance, the states would probably gain more than they would lose under a loan program. Ultimately, states would be financially responsible (through administration of user fees and state payments) for a greater portion of project costs than under current policy. But they could build needed projects according to state priorities with very low requirements for initial capital formation. In the long run, economically efficient construction and operation of water resources infrastructure would result in strengthened state and local economies.

The loan program implicitly recognizes the competitive advantage that the federal government has over state or local governments in financing relatively expensive water projects. Federal borrowing power is greater at lower cost (because of the lower risk involved) than either state or local borrowing power. A loan program could, therefore, offer a wide range of repayment terms to states to accommodate a variety of financial capabilities at the state and local levels. In this respect, the federal loan program appears quite sensitive to state concerns. However, this must be balanced against the increased state burden of evaluating projects, establishing cost recovery systems, and managing projects once they are constructed. Although it is difficult to predict state loan demand and thus the regional distribution of federal funds, a loan program would allow all states to compete for federal resources on an equal footing, eliminating any regional biases resulting from current funding mechanisms.

Effects on Users

Users would pay the full cost of services for marketable benefits. This could represent significant increases in the prices currently paid for federally subsidized water and water project benefits. In turn, users would be induced to conserve water if possible or make other efficiency adjustments motivated by the real, unsubsidized price of water. For example, western farmers receiving subsidized irrigation water under current policy would pay eight times the subsidized price, on average, under a federal loan program. 4/

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4. This estimate assumes that farmers would be willing to pay this higher price. Many would probably not pay so much to irrigate and would revert to dry-land farming. For additional details, see U.S. Department of the Interior, Water and Power Resources Service, Acreage Limitation--Draft Environmental Impact Statement (March 16, 1981). When compared to the effective, composite nonfederal cost-sharing rate for irrigation projects--19 percent--a full cost recovery plan would increase farmers' irrigation costs by a factor of 5, on average.

Shippers on the inland waterways would pay an average of about 16 percent more under full-cost user fees. This could curtail traffic on some waterways. Shippers of soybeans and grain (accounting for about 10 percent of all barge tonnage) would pay about 6 cents per bushel more, most of which would probably be passed back to farmers in the form of reduced prices paid for grain. The cost of shipping coal (accounting for roughly 25 percent of all tonnage shipped on the waterways) would also increase, ultimately raising consumers' electricity bills by about 1 percent.

Shippers using the nation's ports and harbors would also pay more under average user fees set to recover 100 percent of operation and maintenance costs. International shippers would pay about 40 cents per ton more than they now pay, or a 1 percent increase in total shipping costs. Great Lakes shipping costs would increase by about 19 percent and coastal shipping costs by about 7 percent. If users were also charged for new capital projects, costs could increase slightly more. For example, deepening the port of Norfolk would increase user fees by about $1.00 per ton of coal. The increased fees would be more than offset, however, by the anticipated savings from using larger coal-carrying ships. 5/

FEDERAL BLOCK GRANTS

A block grant option--modeled after the 1981 Domenici-Moynihan proposal (S. 621)--could reduce delays associated with federal control over intrastate projects while achieving efficiency gains in constructing interstate projects. In addition to higher nonfederal cost-sharing rates, states would finance a significantly higher share of water project construction.

The federal government would invest in two types of water projects—regional (interstate) projects, and intrastate projects. Regional projects could include large multipurpose reservoirs or projects involving interstate transfers of water serving several states, to the extent that such projects could still be justified on economic grounds. But, since such facilities are largely in place, regional investments would probably focus on rehabilitation and maintenance of the inland waterway system.

Each year, the Congress would appropriate a fixed level of intrastate project funding that would be allocated to the states based on population, land area, or some other proxy for "need." In order to receive these funds,

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5. For additional details, see Congressional Budget Office, "Statement of Alice M. Rivlin, Director, before the Subcommittee on Water Resources of the Senate Committee on Environment and Public Works (May 18, 1983).

states would have to match them with their own funds. Unused allocations would be redistributed to other states according to the original allocation formula. States could use federal allocations for any water resources purpose they chose.

Under the 1981 Domenici-Moynihan proposal, the states would pay a minimum of 25 percent of feasibility study costs, 25 percent of project construction costs, and 50 percent of operation and maintenance costs. If, under existing cost-sharing conventions, the nonfederal share of a particular type of project was higher than these minimum rates, the higher rate would prevail. These minimum rates for project construction and operation are very close to the historical mean nonfederal rates--24 percent of construction costs and 58 percent of operation and maintenance costs. In the past, states did not pay for any study costs. While the "economically optimal" matching ratios under a block grant approach are debatable, for purposes of discussion this option assumes a 50 percent state match for construction and operations and a 25 percent state match for feasibility studies.

States would be responsible for maintaining two priority lists, one for feasibility studies and one for potential construction projects. Each list would incorporate any backlogged projects that the state wanted considered. A project would be placed on the state priority list of authorized projects ready for construction if three conditions were met: the feasibility study indicated a feasible solution to the water problem (on economic, environmental, and engineering grounds), the state certified that the project should be on the list, and there were no objections to construction from neighboring states. If one or more of these conditions were not met, a project could still go forward, but only after Congressional review and authorization.

Regional projects would be selected by a board composed of representatives from the Corps, the Bureau, the TVA, and the SCS, and five members-at-large (recognized experts in regional water resources development). The federal government would pay all costs for regional projects, establish cost-recovery mechanisms for all marketable benefits, and operate the facilities after construction. The board would also serve as a clearinghouse for feasibility and authorization information.

Economic Efficiency under Block Grants

Under the block grant option, economically efficient intrastate projects would be encouraged but not guaranteed. User fees would not be mandatory; a state could choose to subsidize groups of users if it so desired. Block grants for intrastate projects would match costs to beneficiaries only to the extent that matching ratios approximated the ratio of marketable to nonmarketable benefits and to the extent that states chose to pass the correct share of the marketable costs through to users. The generally higher state contribution to intrastate investments, however, would certainly encourage consideration of higher user fees. By contrast, interstate project construction would be conditioned by users' willingness to pay appropriate fees, promoting more economically efficient investments in regional projects.

Under this option, a reduced nonfederal share for hydroelectric power and municipal water supply projects could encourage relatively more of these projects than under current policy. A higher nonfederal share for all other projects, however, could discourage their construction (see Table 6). Overall, states and/or users would end up paying about 22 percent more for water projects than they do now, which in turn could result in more efficient new construction investment decisions. Adjusting the nonfederal share by project type to reflect more nearly the marketability of benefits could also be accommodated within the block grant structure. Potential efficiency gains from doing so would have to be balanced against any increased state financing burden.

The current cumbersome process for feasibility studies and authorizations would be shortened considerably and removed from Congressional consideration, except under limited circumstances. Feasibility study periods could be limited to three years, with authorization 90 days later. Construction could then begin immediately. By comparison, in a study of 115 projects undertaken by the Corps in 1966, it took an average of 10.8 years for a study to move from authorization to approval by Congress and then 6 more years to begin construction after authorization. 6/

Effects on the Federal Budget

This option could have varying effects on the federal budget, depending upon the level of appropriations set each year by the Congress. Unlike the loan program, however, this decision would remain with the Congress, and the federal budgetary exposure could thus be limited. It is reasonable to assume that the fiscal year 1982 level of federal appropriations for water resources--about $3.7 billion for construction and operations--would serve as an initial level of funding under this option. If this were the case, roughly

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6. See U.S. Department of the Army, Office of the Chief of Engineers, "Report of the Chief of Engineers on Survey Report Procedures to the Committee on Public Works, House of Representatives," unpublished paper (April 1966).

TABLE 6. CURRENT MEAN, EFFECTIVE NONFEDERAL CAPITAL COST SHARING RATES COMPARED TO COST-SHARING RATES UNDER THE BLOCK GRANT PROPOSAL, BY PROJECT PURPOSE

	Effective Nonfederal Share of Project Capital Costs		
Project Purpose	Under Current Policy (In percents)	Under Block Grants (In percents)	Net Differences (In percentage points)
Urban Flood Damage Reduction	17	50	+33
Rural Flood Damage Reduction	7	50	+43
Drainage	42	50	+8
Irrigation	11	50	+39
Erosion Control	37	50	+13
Municipal and Industrial Supply	62	50	-12
Water Quality Control	31	50	+19
Fish and Wildlife Preservation	8	50	+42
General Recreation	17	50	+33
Navigation a/	16	50	+34
Hydroelectric Power	64	50	-14
Mean, All Project Types b/	28	50	+22

a. Not including inland navigation projects. These would be funded entirely by federal project grants. Federally administered user fees would recover up to 100 percent of the federal investment.

b. Weighted by level of expenditures within individual project types.

$1.5 billion would be allocated to intrastate projects.[7] If all these funds were matched equally by the states, about $5.2 billion worth of combined federal and state water resources expenditures could be leveraged with federal outlays held at the 1982 level.

Effects On The States

Under a block grant approach, the nonfederal contributions to water projects would have to be provided by the states in the form of either up-front financing or noncash contributions, such as land, easements, or rights-of-way. Under current policy, the nonfederal share is often provided by users over a 50-year period. Thus, block grants with high matching ratios imply an increased financing burden on the states. Before or during construction of an irrigation project, for example, the state would have to provide 50 percent of the capital costs. States would be faced with raising this development capital by appropriating from general revenues (tax collections); issuing development bonds (general obligation or revenue bonds, depending on the type of project); or transferring, in part or entirely, the burden of capital formation to those localities that stand to benefit from the water project.[8]

For some types of projects, the nonfederal financing share would change dramatically under this proposal. For example, the state financing

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7. This estimate was derived by combining that portion of each of the four federal water agencies' 1982 appropriations that funded essentially intrastate projects. Included were the Corps' local flood control projects; portions of several other Corps' accounts, SCS projects constructed under P.L. 534 and P.L. 566; and portions of the Bureau's construction account.

8. State financing of water projects is not new. In 1982, in addition to financial obligations fulfilled by states to participate in federal projects, every state actively funded its own water development projects through various financing techniques, including appropriating funds from general revenue (in 36 states for a total of $490 million), issuing general obligation bonds (in 27 states for a total face value of about $2.4 billion), issuing revenue bonds (in 11 states for a total face value of about $700 million), and dedicating taxes and collecting user fees (in 26 states for a total of about $300 million). For details, see Congressional Budget Office, Current Cost-Sharing and Financing Policies for Federal and State Water Resources Development (July 1983).

share of a rural flood control project would increase by 43 percent. The state share of financing fish and wildlife benefits would increase by 42 percent, and the state financing burden for irrigation projects would increase by 39 percent. For municipal water supply and hydropower projects, the up-front financing burden on the states would be increased substantially over current policy, even though the ultimate burden of payment would actually be lower than it is currently. Although it is arguable that these types of projects should be locally financed anyway, this upward shift in financing requirements could prohibit some states from participating fully in the grant program.

The way that the block grants would be distributed could also have an important effect on the states. Under an allocation formula based on population and land area, historical trends in regional distribution of federal funds would be altered. Southern and western states--the recipients of about 40 percent and 36 percent, respectively, of overall federal water spending between 1956 and 1980--would receive about 31 percent each under the block grant option. Northeastern and north central states, which received about 6 percent and 19 percent, respectively, of all federal water spending between 1956 and 1980, would get about 13 percent and 25 percent under the new block grants (see Table 7). Distribution of federal funding for regional projects could alter these estimates.

Effect on Users

Direct beneficiaries of marketable products from interstate, federally funded water projects would pay user fees to the federal government in an amount sufficient to recover the federal investment. Shippers on the inland waterways, for example, would pay full-cost user fees under this option, with effects identical to those described under the loan program.

Although fees for local port and harbor dredging would not be mandatory under this option, states could choose to impose them in order to recover their increased costs for such projects. Similarly, local projects supplying hydroelectric power and water for agricultural, municipal, or industrial use could cost users more if states chose to recover their increased costs.

FEDERAL PROJECT GRANTS UNDER A LIMITED FEDERAL ROLE

This option recognizes that most of the federally important water projects have already been built and would, therefore, accelerate a transition from federal to state responsibility for new intrastate water project

TABLE 7. REGIONAL DISTRIBUTION OF FEDERAL WATER EXPENDITURES UNDER THE BLOCK GRANT OPTION COMPARED TO THE HISTORICAL DISTRIBUTION

Region	Percent of All Federal Water Expenditures 1956 through 1980	Percent of Federal Funds Under Federal Block Grants a/
Northeast b/	6.0	13.4
North Central c/	18.7	24.7
South d/	39.7	30.8
West e/	35.7	31.1

SOURCE: Congressional Research Service, Environment and Natural Resources Division, unpublished data developed at the request of the staff of the Senate Committee on Environment and Public Works (March 1982).

a. Excluding distribution of federal expenditures for regional projects.

b. Northeastern States: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

c. North Central States: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

d. Southern States: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia.

e. Western States: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

construction. An independent review board would select among projects that were interstate or international in scope (multistate inland navigation or reservoir systems or international stream flow), produced significant benefit or cost spillovers from one state to another (water quality, control, stream flow regulation), or entailed national defense or security benefits (some harbor improvements). Existing projects and those currently under construction that met these criteria would remain under current financing and administrative policies. Financial and administrative responsibility for all other current projects would be transferred to the states over a period of ten years. Any new projects that met the criteria for federal interest would be constructed under current project evaluation, selection, and financing conventions. Federally administered user fees would be instituted to recover the costs of providing marketable benefits. Receipts would accrue to the federal government and to the states in proportion to their financing contribution.

All new water projects that did not meet the criteria for federal interest would be financed and managed by the states, which would be given full authority to levy user fees sufficient to pay for construction and operation. In addition, the states could retain federal agencies under contract for construction, engineering, planning, or other technical support, if they chose to do so. Terms for payment could be based on the actual federal cost of these services.

Economic Efficiency Under a Limited Federal Role

For those new projects judged to be of significant federal interest and offering a marketable benefit, federal funds for construction or operation would be repaid over time by users through a federally administered system of user fees. Hence, matching costs to beneficiaries would condition investments with users' willingness to pay, in turn reducing the tendency for overinvestment in these projects. For federally important projects that produced nonmarketable benefits, current cost-sharing conventions would prevail, and thus some potential would still exist for inefficient federal spending.

Federal project selection would not necessarily become less complicated under this option. The definition of "federally important" is imprecise and open to debate. States or other local project proponents seeking federally subsidized water projects would have an incentive to lobby for their projects by trying to prove that they, indeed, had federally important attributes. Thus, there is potential for this option to become little more than current policy, perhaps with federally administered user fees.

Effects on the Federal Budget

Federal outlays could be reduced significantly under this option. If the fiscal year 1982 level of spending for "federally important" projects was maintained over the ten-year phase-in period, total federal outlays for construction and operation of water projects would drop about 5 percent a year, from $3.7 billion in fiscal year 1982 to about $2.2 billion in fiscal year 1992 (see Table 8). Thus, after the phase-in period, federal outlays would be about 40 percent lower than 1982 spending.

TABLE 8. PROJECTED FEDERAL OUTLAYS FOR WATER RESOURCES CONSTRUCTION AND OPERATION UNDER A LIMITED FEDERAL ROLE (BY fiscal year, in billions of 1982 dollars) a/

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Outlays	3.7	3.5	3.3	3.2	3.0	2.9	2.7	2.6	2.5	2.3	2.2

a. Estimate ignores a further reduction in outlays from offsetting receipts from federally assessed user fees.

Effect on the States

Of the three options discussed in this chapter, this option would put the greatest financial burden on the states, including the added costs of operating and managing existing intrastate projects, financing any new intrastate projects, and meeting existing cost-sharing requirements for federally important projects. Out of about $3.7 billion in federal expenditures for water resources in fiscal year 1982, about $1.5 billion (41 percent) would have been a state responsibility under this option. [9]

To be sure, without federal assistance, some states would be at a significant financial disadvantage relative to other states. Although it is difficult to measure, two types of states could be worse off: those that have relied most heavily on federal subsidies, and those with limited capacity to raise development capital. States with significant energy resources and/or expanding industrial and population bases may have an advantage in raising capital for water projects.

Effects on Users

Direct beneficiaries of federal investments would pay higher prices for water and water services if this option was implemented. Shippers on the inland waterways, for example, would pay an average of 16 percent more under full-cost recovery user fees. If user fees were set by specific segments, several low-volume, high-cost waterways would probably close (namely, Appalachicola/Flint, Kentucky, Ouachita/Red, Arkansas, Tennessee-Tombigbee), forcing shippers to seek alternative rail or truck transportation.

In addition, depending on the response of the states to their new water development responsibilities, beneficiaries of other types of water projects could also pay significantly more for water and related services. Based on current subsidies, farmers could end up paying five times more under full-cost recovery than they now pay for irrigation water; the price of hydroelectric power and municipal water supply could increase by 50 percent; and port and harbor fees for some high-cost, low-volume ports could be high enough to make operations uneconomic. Phasing in higher fees would help reduce sudden economic hardship and allow users to make necessary adjustments to increased costs.

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9. This estimate is based on transferring to the states over a ten-year period the following federal activities: small watershed and local flood control activities of the SCS; up to half of the Bureau's construction activities; the Corps' local flood protection, beach erosion control, and recreation activities; and portions of the Corps' harbor dredging, multipurpose reservoir, major rehabilitation and dam safety, and Mississippi River and Tributaries activities.

Water Resources in Food and Energy Production

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Conflicts for water between US agriculture and energy sectors are projected to increase. Currently agriculture consumes 83% of the water withdrawn, and an increase of 17% is projected by the year 2000. At the same time, a major synfuel program from coal and oil shale could increase water consumption for energy production 4- to 30-fold over present levels. A significant portion of this growth in water demand will occur in the western states where most irrigated agriculture and one-half of US coal reserves are located. Environmental restrictions and the necessity to maintain aquatic ecosystems are additional constraints. *(Accepted for publication 15 June 1982)*

Water resources are both ecologically and economically essential to the United States. Humans must consume 2 to 3 liters of water per day (l/d) for survival. In addition, to maintain the high standard of living in this country, about 7200 l/d (1900 gal/d) of water per person are withdrawn from rivers, lakes, and underground aquifers. Some of this is used directly by individuals and industry, but almost 72% is used to supply food and energy needs (Murray and Reeves 1977, USWRC 1979). In the United States, the production of the 2 kilograms of food consumed per person each day requires about 2700 l of pumped water plus rainfall. The 30 kg of coal equivalents of energy consumed per capita daily requires pumping an additional 2300 l of water.

Water resources in certain US regions are currently overdrawn, especially in the western United States. Drawdown problems over the Ogallala aquifer in the Great Plains (Boddé 1981, Walsh 1980), water deficits along the Colorado River, and water shortages in the San Joaquin Valley are symptomatic of this pressure (Harrison 1977, USDI 1976). Water shortages are also occurring in certain limited regions of the eastern United States where overall water availability is much higher than in the West (Sheer 1980).

Because both agricultural and energy production processes use large quantities of water, their anticipated growth over the next two decades is expected to tax US water resources as well as many natural ecological systems. Specifically, by the year 2000, food production is projected to increase about 30% to meet domestic and export food needs (ERAB 1981). Projections are that biomass energy production systems will increase from 5- to 20-fold by the year 2000 (ERAB 1981, OTA 1980a) while synfuels from coal and oil from shale might increase from 2- to 5-fold (Livingston et al. 1981, NAS 1979). Indeed, water will be one of the limiting factors of energy production in the future (Harte and El-Gasseir 1978, NAS 1979).

In this report some of the current and future constraints that water shortages may impose on food and energy production are assessed. These include: the availability of usable water in the United States, the current and projected water consumption demands for the agriculture and energy sectors, and the environmental impact of water use on aquatic ecosystems and natural resources. Although many sectors of society require water and may experience water deficits, the analysis is primarily focused on use of water in food and energy production because these are the major consumers of water in the United States.

WATER AVAILABILITY

An estimated 152,000 billion liters per day (bld) of water vapor drift over the continental United States; about one-tenth of this water precipitates daily (USWRC 1979). Nearly two-thirds of this precipitation is converted back into water vapor by transpiration by plants and evaporation from other surfaces (Garstka 1978, Nace 1976), leaving about 5000 bld of surface and subsurface flow.

The US Water Resources Council (USWRC 1979) estimates that a maximum of 2600 bld of average annual stream flow is available for use. At seasonal low flow periods, only 1350 bld are available nationwide for consumption. The limited available surface storage present in lakes and reservoirs, as well as variable rainfall, make it difficult to increase the available surface supply of water. The construction of additional reservoirs is not practical at present because most of the large, economically and hydrologically feasible reservoir sites have already been developed (Nace 1976).

Water also is available from groundwater; about 10 times more fresh water is stored underground than on the surface in the United States. Estimates of the amount of groundwater range as high as 2.30×10^{17} l, with about 58×10^{12} l of this considered usable (Akerman and Lof 1959).

In general, replenishment of groundwater by rainfall is quite slow. Annually only about 230 bld or <1% of the store of groundwater is replaced (CEQ 1980a). Groundwater that has accumulated over millions of years is being mined today to offset surface and groundwater deficits resulting from population growth and expanded energy and agricultural uses. Thus, withdrawal of groundwater exceeds natural water recharge and recy-

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cling. For example, in 1975 about 310 bld of groundwater was pumped (USWRC 1979). In the coterminous states, water overdraft exceeded replenishment by about 80 bld, or 25%; and in the Texas-Gulf area, overdraft is as high as 77%.

CURRENT WATER USE

An estimated 1600 bld of water is withdrawn daily from US water resources, excluding that needed for hydroelectric uses (Murray and Reeves 1977). Of this, about 62% is fresh water withdrawn from surface sources; 20% is from fresh groundwater; 16% from saline surface water; and 2% from saline groundwater. Of the total water withdrawn, the industrial, energy, and agricultural sectors pumped 92%, and public and rural water supplies pumped the remaining 8% (Figure 1).

About 77% of the water withdrawn from surface and subsurface sources is returned to rivers and lakes (Murray and Reeves 1977). The remaining amount or 360 bld of the water that is withdrawn is consumed or lost. Most of this water is lost simply by evaporation and transpiration and is no longer directly available for reuse. Of the estimated 360 bld consumed, only 296 bld can be considered renewable in terms of daily flow based on demand and calculated regional availability of water (Figures 1, 2, and 3). Renewable means that groundwater sources are not reduced and that no more than 40% of the mean annual flow of instream water is depleted so natural aquatic systems are not seriously affected (Tennant 1976).

Agricultural irrigation consumes 83% of the total of 360 bld that is consumed or lost (Figure 1). Most of the water consumed by agriculture is lost by transpiration and evaporation. The public, industrial, and rural sectors consume the remaining 17% of the total (Figures 1 and 3).

On a per capita basis, an estimated 7200 l/d of water is withdrawn for each American (Table 1). Note that the per capita withdrawal in the western region is twice that in the eastern region. The major difference between these regions is in water consumed, with more than 12 times as much fresh water consumed in the West than in the East. The high rate of consumption in the West, primarily for irrigation, accounts for both the water imbalances and the mining of groundwater to offset water deficits (USWRC 1979).

Withdrawals and consumption are expected to increase, especially in western areas (USWRC 1979). The highest projected increases in domestic consumption are for four regions: the Texas Gulf, lower Colorado, Great Basin, and California (Figure 2). Although these regions account for 30% of the projected increase in domestic water consumption, California alone accounts for 20%. This trend in water consumption parallels expected population growth in the sunbelt areas of the United States.

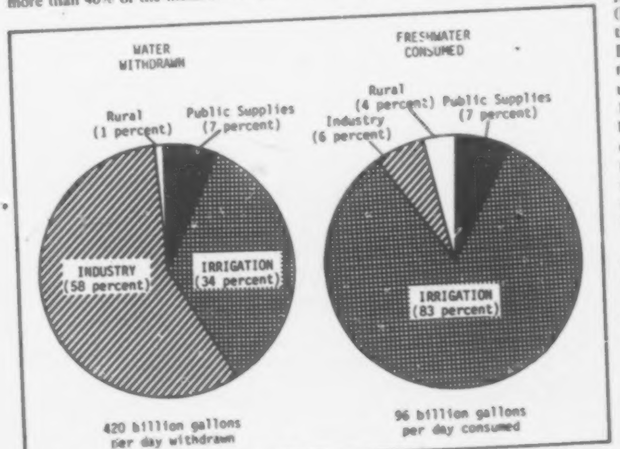

Figure 1. Off-channel water withdrawals in the United States and the proportion of freshwater consumed in 1975 (after Murray and Reeves 1977).

Because US society as a whole is such a large consumer of goods, it is easily understood why industrial water use per capita is high (Figure 1). Industry consumes about 10% of the total amount of water it withdraws (USWRC 1979). The amount of water used to produce different products is varied, but often is surprisingly large. For example, the production of an automobile requires 45,000–61,000 l of water and a single glass bottle requires 450–2500 l (Chanlett 1979).

Manufacturing industries withdraw about 193 bld of water (USWRC 1979). Almost 90% of this water is associated with industries located in the eastern portion of the United States. Fortunately, the water is recycled and reused within the plants an average of 2.2 times before it is discharged (USWRC 1979). Although pollution controls undoubtedly will encourage water recycling within industrial plants, water consumption is still expected to more than double by the year 2000 (USWRC 1979).

Water Demand for Food Production

Water is one of the major limiting factors for agricultural production. Although sufficient rain falls upon eastern US agricultural land, periodic drought continues to limit yields as was evident in the summer of 1980. Crops require and transpire massive amounts of water; for example, a corn crop that produces 5600 kg of grain per hectare will take up and transpire about 2.4 million liters of water per hectare during the growing season (Penman 1970). Irrigated crop production requires large quantities of water. For example, the production of 1 kg of the following food and fiber products under irrigation in California requires: 1400 l for corn, 1900 l for sugar (sugar beets), 4700 l for rice, and 17,000 l for cotton (Ritschard and Tsao 1978). Water needed to produce 1 kg of grain-fed meat ranges from about 4200 to 8300 l when the water input for irrigated grain is included.

In total, agriculture withdraws 600 bld annually (USDA 1980a). Irrigation accounts for 99% of this total, whereas livestock uses only 1%. In the nation as a whole, surface water supplies about 60% of the water used in irrigation and groundwater provides the remainder (Murray and Reeves 1977); however, major regional variations exist with some states pumping as much as 94% of their irrigation water from groundwater (Dvoskin and Heady 1976). About 16% of the irrigation water does not reach the

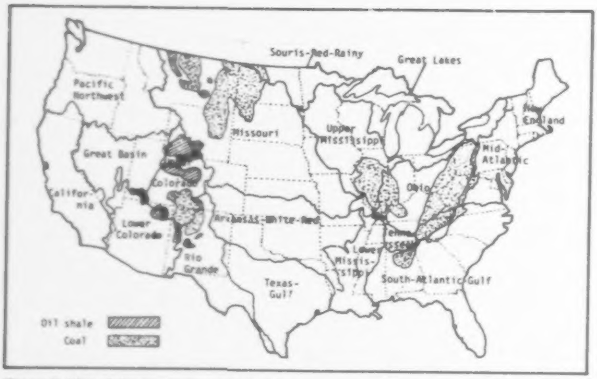

Figure 2. Map of the conterminous United States showing Water Resources Council regions and major coal and oil shale deposits (after Harte and El-Gasseir 1978, USWRC 1979).

intended crop; about one-third of this is lost by evaporation and the remainder by seepage and percolation during transport (Murray and Reeves 1977).

Although only about 12% of US cropland is irrigated, this land produces about 27% of the total dollar value of US crops (USDA 1980b). Most irrigated crop production is regionally concentrated. Seventeen western states contain nearly 90% of the irrigation hectarage in the United States (USDI 1979) and use about 93% of the irrigation water that is withdrawn in the nation (USWRC 1979). Considerable water must be supplied to crops grown in arid regions, and water demand is increased in these regions by high evapotranspiration rates. For instance, from 20–40% more water is used by crops grown under arid conditions than under normal moist conditions[1] (Arkley 1963).

In addition to water use, irrigated crop production is costly in terms of energy. The total energy used to supply each person annually with food is about 1500 l of oil equivalents (17% of per capita energy consumption) (Pimentel and Pimentel 1979). Nearly one-fifth of all energy consumed in agricultural production moves irrigation water (USDA 1974). In Nebraska, rain-fed corn production requires about 630 l/ha of oil equivalents, whereas irrigated corn requires about 1900 l/ha of oil equivalents or almost three times more energy (Pimentel and Burgess 1980).

The heavily subsidized federal and state-sponsored irrigation-water projects also consume large quantities of energy in addition to that used by farmers for irrigation (Anonymous 1982). Significant energy inputs for irrigation are hidden in subsidized dam and waterway construction; energy inputs for such construction may account for an additional 10% of the energy used for surface irrigation water supply (Roberts and Hagan 1975). In addition, significant quantities of energy are used to lift water over mountain ranges in some regions of the West. In the San Diego River basin, for example, the surface water supplied through the Colorado River Aqueduct requires about 185 l of oil per 1.2 million l for this lift (Roberts and Hagan 1977). This increases from 2- to 10-fold the total energy input for irrigation water in some areas.

The total cost of energy used to pump irrigation water in the United States rose from about $350 million in 1973 to more than $1 billion in 1977 and represents a nearly three-fold increase (Sloggett 1979, USBC 1979). In certain locations where groundwater depth is great, the energy costs of pumping water may be another limitation to irrigation.

In the West surface water for irrigation ranges from $10 to $15 per million liters (OTA 1980b), whereas groundwater costs about $30 per million liters (USDA 1981). Pumping groundwater from depths of 180 m increases the cost to about $60. If 3.6 million liters per hectare of groundwater were used during the growing season, then the cost of water alone might range as high as $450/ha. Therefore, as fuel prices escalate, irrigated agriculture will face economic difficulties. This pressure is already being felt. For example, in the Trans Pecos region of Texas, because of the increase in irrigation and other production costs, crops like alfalfa, barley, sorghum, and wheat returned less than the breakeven price (Patton and Lacewell 1977). Also, in Arizona, the high price of fuels for irrigation is forcing some growers to abandon the production of low-value crops like alfalfa (Larson and Fangmeier 1977).

The quantities of irrigation water applied to cropland can be reduced by employing various technologies. Surface application uses the largest quantity of water and drip irrigation the smallest amount (Batty and Keller 1980). Drip irrigation delivers the needed amount of water directly to each individual crop plant, but piping the water to each plant is energy costly in terms of capital equipment. Drip irrigation, however, saves energy where high lifts are involved because pumping energies are much larger than installation energies (Batty and Keller 1980). Clearly, several opportunities exist to improve irrigation technologies to conserve water and energy (Batty and Keller 1980, Chen et al. 1976, Stanhill 1979). Future shifts in irrigation technology and crops will probably reduce both water and energy use per irrigated crop hectare.

Table 1. Per capita water withdrawals and water consumed in the eastern and western Water Resources Council regions (Figure 2) of the United States in 1975 (Murray and Reeves 1977).

	Public water supplies			Totals	
	Population served* (millions)	Per capita withdrawals (l/day)	Total pop. (millions)	Per capita withdrawals (l/day)	Fresh water consumed (l/day)
Eastern region	120.9	610	151.7	5700	370
Western region	50.8	720	61.3	11,400	4900
50 states	172.7	640	214.2	7200	1670

*Remaining population is served by private water supplies primarily from wells.

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[1] L. D. Swindale, ICRISAT, Hyderabad, India, personal communication, 1980.

Water Demand for Energy production

During 1975, electric power plants withdrew a calculated 520 bld, 33% of the nation's total water withdrawals; this amount is projected to increase to about 760 bld by the year 2020 (USWRC 1979). Although power plants pump a large proportion of the country's water, they are responsible for only 2% of the total national water consumption, since most of the water is returned (Loftness 1978).

As US oil and natural gas reserves continue to decline during the coming decades, a shift to coal-derivatives and oil shale will probably occur to supply the nation's energy needs (Livingston et al. 1981, NAS 1979). However, this shift to synthetic fuel use faces several obstacles. One major problem is the large quantity of water needed for the production of synthetic fuels from coal and oil shale. Although synfuel production technology is still in the developmental stage and exact water requirements are unknown, the estimates require large quantities of water. Water is used in mining coal and shale, in the conversion process to high-grade fuel (oil or gas), and in waste treatment and land reclamation (Table 2). For example, 25–75 l of water per metric ton of mined coal are used for dust control and washing the mined coal. In addition, coal liquefaction consumes 1200–7500 l per barrel (42 gal or 159 l) of synfuel produced (Table 2). The water consumed in synfuel production from coal includes water used for the following purposes: mining (1%), reclamation (15%), transport of slurry in pipelines (15%), conversion process (60%), and associated urban uses (9%) (Harte and El-Gasseir 1978, OTA 1978).

Using coal to produce synthane gas consumes 620–3900 l of water per million kilocalories of synthane produced (Table 2). Converting coal energy into gas or syncrude is about 68% efficient (NAS 1979). Thus, each metric ton of converted coal produces the equivalent of about 900 l (5.7 bbl) of oil and consumes 870–7400 l of water.

The production of oil from shale consumes less water than producing synfuels from coal (Table 2). The energy potential, however, of oil shale is estimated to be much less than synfuels from coal (NAS 1979). The water consumed per million kcal of oil from shale is calculated to be 470 l, or 680 l per barrel of oil (Table 2) and the largest water input (46%) is for land reclamation (Harte and El-Gasseir 1978). Such a high water requirement for reclamation is due to the difficulty in revegetating the large areas of barren rubble that result from processed shale. The volume of processed shale is about 1.2 times greater than the raw shale, creating a major environmental problem.

Earlier, it was mentioned that agriculture uses about 300 bld of the total 360 bld water consumed and that the highest use occurs in the western United States. Therefore, a major synfuel energy conversion program using coal or oil shale to produce oil and/or gas may seriously compete with agriculture for water in western regions of the country (Bishop and Narayanan 1979) (Figure 2). Energy producers will have significant difficulty in securing a share of the western water where agriculture is the "major user of diverted water in the West, accounting for 90% of water consumption" (Radosevich 1979, p. 3). Western water laws are based on the concept of "first in time, first in right" instead of riparian access, as in the East. Currently most western water rights are allocated to agriculture, primarily for irrigation.

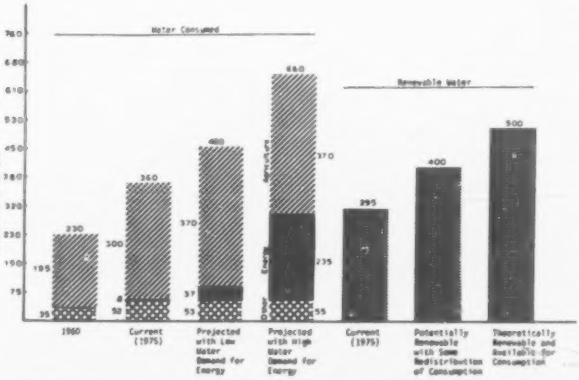

Figure 3. Water consumption levels for 1960 and 1975 by agricultural and energy producers and others (Murray and Reeves 1977, USWRC 1979). The projected water consumption levels after 2000 with proposed agricultural and energy programs are indicated. In addition, the various renewable water projections are shown; it should be noted that none of these estimates of renewable water resources would result in ground-water mining or depletion of minimal stream flows for wildlife and aquatic ecosystems (USWRC 1979).

WATER USE AND AQUATIC ECOSYSTEMS

Many aquatic ecosystems have been either destroyed or are now under stress from competing water needs for agriculture, energy, domestic, and industrial purposes. In areas of the West, for instance, when more than 40% of the mean annual flow of instream water has been depleted, a suitable habitat for most aquatic life cannot be maintained (Bayha 1976, Tennant 1976). Examples of such problem areas are the lower Colorado River, where nearly 80% of the instream flow has been depleted, and most ecosystems in southern California, Nevada, Arizona, New Mexico, Colorado, and western Texas, where about 70% of the instream flow has been depleted (USWRC 1979).

Aquatic ecosystems are also affected by heavy pumping of groundwater (CEQ 1980b), which is associated with salt water intrusion into the freshwater reserve and is occurring on Long Island and along the coast of California, Georgia, and Florida (Anderson and Berkebile 1976, Hammer and Elser 1980, West 1980). Another major problem associated with groundwater overdraft is "subsidence," that is, the settling of the land as water is pumped from the ground. In some regions, such as San Joaquin Valley, California, where irrigation pumping is heavy, the land already has settled 9 m (Bouwer 1977). This subsidence is irreversible once it occurs and may result in sufficient stress to cause faulting similar to the San Joaquin Valley and elsewhere (Kreitler 1977).

Special pollution problems result from irrigated agriculture when river and

Table 2. Water requirements for producing energy as coal and synthetic fuels.

Energy source	Consumption for water	Water needed (l/10^6 kcal)	Uses included	Source
Western coal mining	25–62 l/t*	4–9	Dust control, coal washing	USWRC 1974
Eastern surface mining	67–75 l/t	10–11	Dust control, coal washing	USWRC 1974
Oil shale (mine retort)	680 l/bbl	470	Mining and processing	EPA 1979
Coal gasification (synthane)	6 × 10^6–36 × 10^6 l/MCM†	620–3900	Mining, processing, and reclamation	Gehrs et al. 1981
Coal liquefaction	1200–7500 l/bbl	810–5100	Mining, processing, and reclamation	Gehrs et al. 1981

*metric tons
†million cubic meters

stream water is degraded by the addition of salts. For example, when the Colorado River flows through Grand Valley and water is withdrawn for irrigation and later returned to the river, an estimated 18 t/ha of salt are leached from the irrigated land and added to the river water (EPA 1976). At times during the summer, the Red River in Texas and Oklahoma is more saline than seawater, mainly due to irrigation use and normal evaporation (USWRC 1979).

Energy production from coal and shale may also increase water pollution. Water pollution from coal and shale oil comes from point and nonpoint sources, including cooling water discharges, spills, pipeline leaks, and leaching of the aboveground waste disposals (Gehrs et al. 1981, OTA 1980b). Spent shale in aboveground retorting will probably be leached by rainfall, and this alkaline residue contains significant amounts of sulfate, carbonate, and bicarbonate, as well as traces of other organic compounds (OTA 1980b).

From mining to electrical generation, the use of coal can also result in pollution problems. Acid runoff from mines and spoil banks may pollute nearby streams and watersheds. Coal mining may also reduce groundwater supplies and pollute groundwater through acid drainage (Elliot 1981). Revegetation of the strip-mined land is often difficult. In addition, coal combustion is a major source of air pollutants including particulates and oxides of sulfur and nitrogen. The large amount of sulfur dioxide and nitrous oxides in the atmosphere results in "acid rain" (NAS 1981). The ecological effects of acid rain include toxic conditions for some beneficial plants, including crops, insects, and fish.

Surface and groundwater pollution is clearly a hazard to the environment and public health. In addition, economic costs associated with cleaning water for use and reuse are significant. For instance, the costs of conventional treatment of potable water normally range from \$0.11 to \$0.22 per 1000 l (Clark 1979), but may be as high as \$0.33 per 1000 l[2]. If salts must be removed, the costs are about \$0.21 (EPA 1980) and the treatment of sewage for release into streams and lakes costs about \$0.08 per 1000 l (EPA 1980). Thus, environmental sensitivities to pollution are expected to be important constraints to future water development or agricultural and energy production.

PROJECTIONS AND CONCLUSIONS

Both water withdrawals and consumption have been growing steadily since 1950 and are projected to increase each year in the future (USC 1979, USDA 1980a). Some sources project a slight decline in fresh water withdrawals but an increase in overall consumption (USWRC 1979). From 1950 to 1975 per capita water withdrawals increased more than 45% (Murray and Reeves 1977). From 1960 to 1975 water consumption increased 57%, and the western region experienced the major increase in this growth (Figure 3).

Water consumption by industry and the general public will rise, but the major growth in water consumption is projected for agricultural and energy production. Agricultural use of water will grow because of a projected 30% increase in crop and livestock production by the year 2000 in the United States (ERAB 1981). Some factors contributing to agricultural growth include: increased food exports (estimated to be \$45 billion for 1981) to help offset the nation's oil imports, the rise in per capita use of food crops (USDA 1980c), and US population growth (USBC 1979). Projections are that fresh water consumption in agriculture will increase about 17% from 1975 to 2000 (USWRC 1979).

In addition to agricultural needs, liquid and gas synfuel production from coal and shale oil resources will require large inputs of water in the future with major development probably not taking place until after the year 2000. To put synfuel production from coal into perspective, assume that the nation moved to meet its total current oil and gas needs by coal conversion. Based on the available data associated with synfuel production from coal (Table 2) and producing 10 × 10^{15} kcal of oil and 5 × 10^{15} kcal of gas (DOE 1978), increased water consumption is calculated to range from 30 to 230 bld (Figure 3). The nation is currently consuming 360 bld, therefore water consumption would increase 8–64%, and a significant percentage of this could be expected to occur in the West where water shortages already exist. Another option is to transport the coal to locations where water is available for processing for synfuel production; however, this raises the energy costs.

If the projected growth in agricultural and synfuel programs is combined, the total water consumption increase could be 83–280 bld by the year 2000. With these scenarios, projected total water consumption by the nation might range from 460 to 660 bld (Figure 3). Note that both of these projections are greater than the quantity of water (400 bld) that is potentially renewable with some redistribution of consumption in the nation. The projected high water demand for energy production is greater than the quantity of water (500 bld) that is theoretically renewable and available for consumption. Increases of the magnitudes mentioned for energy and agricultural production can be expected to lead to serious conflicts in water use that will be especially intense in regions where water supplies are already short. Water consumption problems for the future can be better understood by examining current water deficits. Note that current water consumption is 360 bld, whereas current renewable water resources without groundwater mining and surface water depletion are estimated at only 295 bld (Figure 3).

All sectors of the US economy, however, are projected to continue to grow and consume more water. The rates and patterns of growth of these sectors will probably be limited both by the dollar cost and availability of water. As a result, the current priority for water in agriculture in some regions could decline because of the economics of water use in crop and livestock production. For example, corn currently sells for about \$0.11/kg and about 900 l of irrigation water may be required to produce a kilogram under arid conditions. Assuming that 1000 l of water cost only \$0.025, then about \$1 of water produces about \$5 worth of corn (assuming no other input costs). Compare this to synfuel energy production where \$1 of water produces a product worth about \$350 (assume 4000 l of water is used to produce one barrel of oil worth \$35 [Table 2]). The dramatic difference in economic value of product would enable energy producers to pay much higher prices for the essential water than farmers. Cost/benefit analyses will probably favor the more profitable industrial uses of water over agricultural uses (Richard 1978).

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[2] J. Rogers, Engineer, Village of Cayuga Heights, NY, personal communication, 1980.

In some regions water tables will continue to decline and in turn pumping costs will rise. Pumping costs in some regions could well exceed any extra benefits of increased crop yields due to irrigation. Larson (1981) predicts that 1.4 million hectares of land irrigated from the Ogallala formation in the Great Plains will be converted back to dryland farming by the year 2000, and as a result food crop yields will probably be reduced 60% in these regions.

With the lower economic return on water for agricultural purposes, some displacement of water use from agriculture can be expected. This change is already occurring. For example, in Pinal County, Arizona, nearly 41,000 ha or "more than one-third of the area's irrigated acreage have gone out of production" (Wiegner 1979, p. 59). Trends like this will likely continue and will be primarily associated with low-value crops like alfalfa and other forages. Reduced forage production in the West where water supplies are already short could result in increased forage production in the eastern United States. Such a shift in forage production would probably be followed by a shift of some livestock production to the East.

The problem of water allocation is by no means a problem specific to the United States. As many as 80 other countries, which account for nearly 40% of the world population, now experience serious droughts (Kovda et al. 1978). Although the amount of water withdrawn per capita on a global basis is less than a third of US per capita use, the growth in world population can be expected to double water demand by the year 2000 (CEQ 1980a). Agricultural production is projected to consume an estimated 64% of total water withdrawn.

Not only will there be internal competition for water use, but this will extend to conflicts between nations that share common water supplies. In fact, about one-third of the major world river basins are shared by three or more countries (CEQ 1980a). Given current world food shortages and the additional pressures of rapidly growing human population, more water will be needed for both agriculture and energy production.

Next to sunlight and land itself, water is the most vital resource for agricultural production. In the next two decades, US agricultural production will probably expand about 30% to satisfy food needs for the nation and food exports, resulting in an estimated 17% increase in water consumption over current levels. If the nation then makes a major commitment to synfuel production after the year 2000, 8–64% more water would be needed. A significant portion of this growth in water demand is projected for the western states where most irrigated agriculture and one-half of US coal reserves are located. Water shortages and environmental limitations compound the problems. Because of water availability and distribution in the nation and possible conflicts arising among regions and programs, a national water policy based on both ecology and economics should be developed to insure equitable and effective use of water.

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CLEAN WATER FOR TODAY:
What is Wastewater Treatment?

This publication has been prepared by the Water Pollution Control Federation to educate the reader about an integral part of the Nation's infrastructure, the wastewater treatment plant. The contents describe the typical publicly owned treatment works (POTW) found in an average municipality. The first seven pages of the publication explain the actual treatment process. The remaining pages address related topics important to the operation of a POTW.

What is WPCF?

The Water Pollution Control Federation (WPCF) is a non-profit educational and technical association. WPCF is not a lobby. It accepts no federal funds for its programs so that it may provide Congress and the public with objective assessments of our national water pollution policies. The Federation is composed of 40 member associations in the U.S. and Canada. It is affiliated with 25 similar organizations throughout the rest of the world. WPCF's 30000 members include engineers, biologists, chemists, government officials at all levels, treatment plant managers, consultants, pollution control equipment manufacturers, contractors, industrial dischargers, academicians, and students interested in clean water.

For More Information

The following sources were consulted for this publication:

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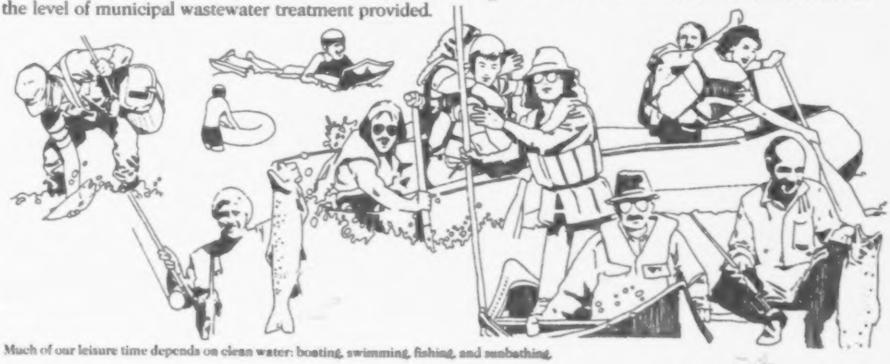
Wastewater Treatment:
The Cornerstone of Clean Water

Over a decade ago, Congress passed the Federal Water Pollution Control Act Amendments of 1972. While the federal government has been increasingly involved in wastewater treatment since the first comprehensive but weak law enacted in 1948, many state and local efforts go back to the early 1900s. The 1972 statute evolved naturally from two major precursors passed in 1956 and 1965. That statute was one of several environmental protection laws passed in the early 1970s. In each instance, the legislature was responding to a widespread concern that unregulated pollution of America's natural resources would significantly degrade the quality of life in the United States. Interest in water pollution control has remained at a very high level over the intervening period. Public opinion polls continue to show that the electorate appreciates the value of a cleaner environment. What is equally important: they are willing to pay for it, too.

There are many "fronts" in our national campaign to "...restore, and maintain the physical, chemical, and biological integrity of the Nation's waters..." One of the most active but least understood has been the field of wastewater treatment. Since 1972, we have invested over $38 billion in public funds to improve the level of municipal wastewater treatment provided. Wastewater treatment services are largely taken for granted, however. Few people realize how complex treatment operations are, how useful some of the byproducts can be, or what an amazing bargain this public service has become.

Wastewater treatment facilities appear to be complicated arrangements of machines, pumps, pipelines, tanks, and towers. But for all of their complex appearance, treatment plants are designed to do two basic things: speed up the natural purification processes that occur in our streams, rivers, and lakes and remove toxic contaminants that might otherwise interfere with the natural processes. For over 80 years, professionals in the clean water field have studied these natural processes exhaustively. Treatment technology is altered and refined to reflect new discoveries. Yet the goal of most wastewater treatment operations remains the same: to produce a stream of treated water that is safe for return to the environment.

Touring such a facility is a short course in sanitary engineering, aquatic biology, organic chemistry, and public administration. A treatment plant is a reflection of all our water pollution control efforts. It is the point at which law, science, and politics combine in a direct expression of public policy. The changes in water quality that occur at a treatment plant vividly illustrate what the goal of our Clean Water Act means in real terms.

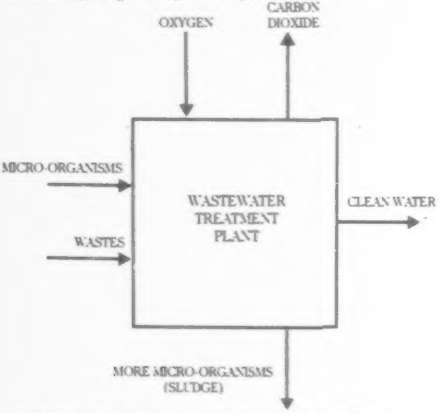


Much of our leisure time depends on clean water: boating, swimming, fishing, and sunbathing.

Water Quality and Wastewater Treatment:

A Crucial Interaction

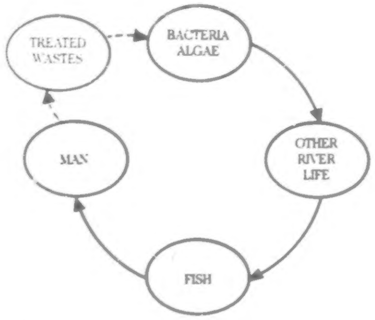
What happens in a wastewater treatment plant is essentially the same as what goes on naturally in a stream or lake. The function of the wastewater treatment plant is to speed up the natural processes by which water purifies itself. In the natural process, bacteria and other small organisms in a stream or lake are attracted to wastewater as a food source. While consuming the food, these organisms produce new bacterial cells, carbon dioxide, and other products. As the wastewater is consumed, the bacteria also consume oxygen. A natural body of water acquires this all-important oxygen by absorbing it from the air and from aquatic plants that use sunlight to turn carbon dioxide present in the water into oxygen (photosynthesis).



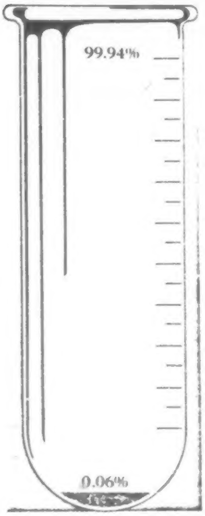
Activities in a wastewater treatment plant closely resemble those which occur naturally in a river or lake.

The life and death of any body of water depend mainly upon its ability to maintain a certain amount of dissolved oxygen. If only a small amount of wastewater enters a stream, natural bacteria can consume the wastes and fish are not affected; the stream can quickly restore its oxygen loss from the atmosphere and from plants. Trouble begins if the amount of wastewater discharged to the stream is so great that bacteria consuming the wastes rob fish and other beneficial life of oxygen.

With the growth of the Nation, the volume of wastewater has increased beyond the level that the natural process can absorb and purify itself. Wastewater treatment facilities are used as supplements to the natural process. In a wastewater treatment plant, bacteria and other organisms consume the wastes, just as in the natural process, but under more controlled conditions. Once most of the wastes have been removed by the bacteria, the treated water can be discharged without harm to the receiving stream.



Biological cycle of a stream shows the interrelation of man, his wastes, and stream life.



Most wastewater is about 99.94% water: only 0.06% is waste.

What is Wastewater?

Basically, **wastewater** is the flow of used water from a community. The name is apt, for wastewater is actually 99.94 percent water by weight. The rest, 0.06 percent, is material dissolved or suspended in the water. The suspended material is often referred to as suspended solids to differentiate it from the dissolved contaminants.

Since dissolved oxygen is the key element in the life of a body of water, it is important to measure how much oxygen will be used by **bacteria** to consume a particular wastewater. The measurement of the required oxygen is called the **biochemical oxygen demand** (BOD) test. The higher the BOD, the more oxygen will be demanded by the bacteria as they consume the wastes. The removal of BOD is a major goal of wastewater treatment.

Occasionally wastewater may contain substances which cannot be consumed by microorganisms, and therefore, are not part of the BOD. Examples are pesticides, heavy metals, and nutrients. Since these substances may have adverse health effects in downstream water supplies, it is sometimes necessary to use complex, auxiliary processes to remove what the bacteria cannot consume.

Wastewater contains harmful, disease-causing (pathogenic) bacteria, viruses, and other microorganisms. Accordingly, another important concern in a treatment plant is the removal of as many pathogenic organisms as possible through disinfection before the wastewater is discharged.

As noted earlier, municipal wastewater is usually 99.94 percent water; thus the concentrations of the constituents discussed are very low. These concentrations are usually discussed as milligrams of pollutants per liter of water (mg/1). One mg/1 of a constituent is equivalent to one part of the constituent (by weight) in one million parts of water—or, as expressed in another often-used term, one part per million (ppm). One mg/1 or one ppm, to put these terms in perspective, is equivalent to one minute of time in 1.9 years, or one inch in 16 miles. These statistics emphasize that wastewater treatment processes designed to remove a few milligrams per liter of pollutant are similar to sifting a haystack to remove a needle. However, the balance in nature for survival or death of fish depends on the presence or absence of only 2-3 mg/1 of oxygen in a stream or lake. A minimum of 4-5 mg/1 of oxygen is usually recommended to maintain good fish populations.

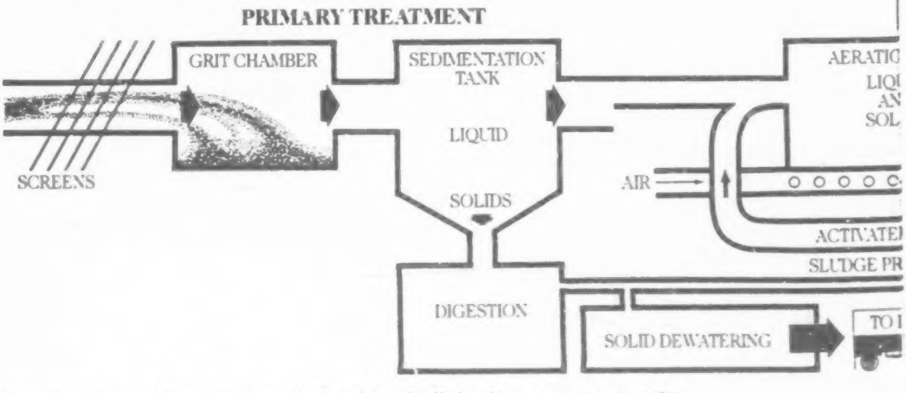
A Typical Treatment Plant:
Clean Water Step By Step

A generally accepted estimate is that each individual, on a national average, contributes approximately 50 to 100 gallons of water per day to a community's wastewater flow. While most people think of wastewater as only **"sewage,"** wastewater also comes from other sources—commercial, industrial, and storm and ground water. Generally, each house or business has a pipe or sewer which connects to a network of larger sewers which carry the wastewater to the wastewater treatment plant. **Sanitary sewers** carry only domestic and industrial wastewater, while **combined sewers** carry wastewater and stormwater runoff. Every reasonable effort is made to exclude storm (inflow) and ground (infiltration) water from the sanitary sewer system. These efforts are usually less successful on older sewer systems that leak.

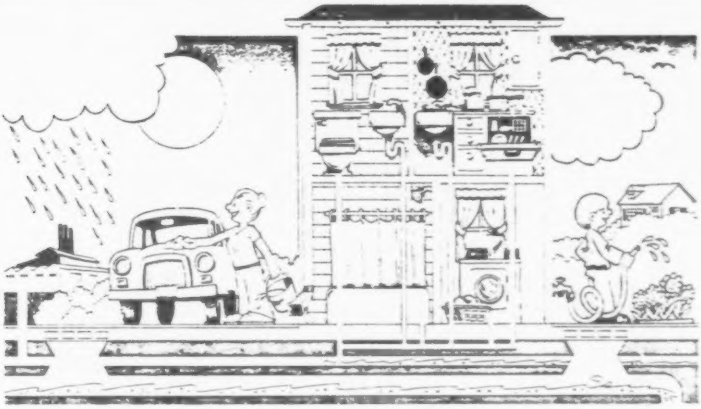
The wastewater from the sewer system either flows by gravity or is pumped into the treatment plant. Usually, treatment consists of two major steps, primary and secondary, along with a process to dispose of solids removed during the two steps.

In **primary treatment**, the objective is to physically remove suspended solids from the wastewater either by screening, settling, or floating. The major goal of **secondary treatment** is to biologically remove contaminants that are dissolved in wastewater. In secondary treatment, air is supplied to encourage the natural processes of growth of bacteria and other biological organisms to consume most of the waste. These organisms and other solids are then separated from the wastewater. Before discharge to the **receiving stream**, the water usually passes through a tank where a small amount of chemical is added to disinfect the treated water.

In primary and secondary treatment, solids are settled and removed for further processing. Solids, usually referred to as **sludge**, are normally processed in three steps—digestion, dewatering, and disposal. The digestion step reduces the potential for emission of odor and prepares the sludge for further processing. Dewatering involves the application of a variety of processes that can reduce the water content of the sludge and in turn, its volume. The final step is the ultimate disposal of the sludge.

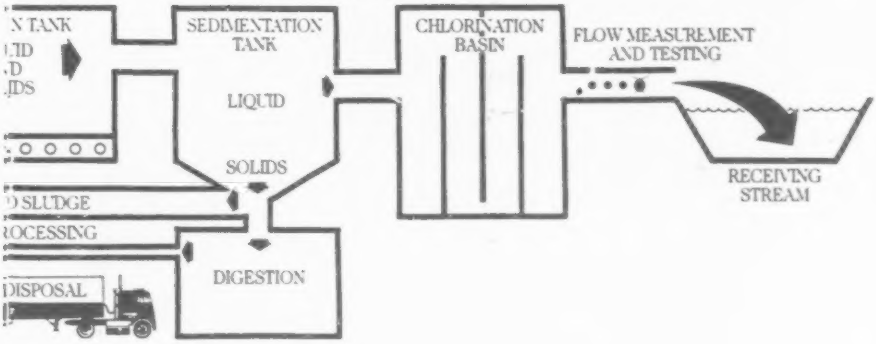


Most secondary treatment plants use a combination of mechanical, physical, and biological processes to restore water quality.



We create wastewater when we use water as a way to transport wastes away from our businesses and homes.

SECONDARY TREATMENT



Primary Treatment:
Physics First

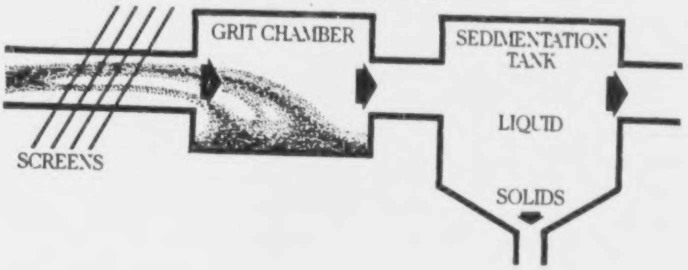
Wastewater entering a treatment plant receives primary treatment first. In this stage, a series of operations removes most of the solids that can be screened out, will float, or will settle.

Screening removes large floating objects from the incoming wastewater stream. Treatment plant screens are sturdily built to withstand the flow of untreated wastewater for years at a time. Rags, wood, plastics, and other floating objects could clog pipes and disable treatment plant pumps if not removed at this point. Typically, screens are made of steel or iron bars set in parallel about one-half inch apart. Some treatment plants use a device known as a comminuter which combines the functions of a screen with that of a grinder.

Sand, grit, and gravel flow through the screens to be picked up in the next stage of primary treatment—the grit chamber. Grit chambers are large tanks designed to slow the wastewater down just long enough for the grit to drop to the bottom. Grit is usually washed after its removal from the chamber and buried in a landfill.

After the flow passes out of the grit chamber, it enters a more sophisticated settling basin called a sedimentation tank. Sedimentation removes the solids that are too light to fall out in the grit chamber. Sedimentation tanks are designed to hold wastewater for several hours. During that time the suspended solids drift to the bottom of the tank, where they can be pushed into a large mass by mechanical scrapers and sucked out of the bottom of the tank. The solids removed at this point are called primary sludge. The primary sludge is usually pumped to a sludge digester for further treatment. During the sedimentation process, floatable substances, such as grease and oil, rise to the surface and are removed by a surface skimming system. The skimmed materials are either sent to the sludge digester for treatment along with the primary sludge or are incinerated. Sedimentation marks the end of primary treatment. At this point, most of the solids in the stream that can be removed by the purely physical processes of screening, skimming, and settling have been collected. An additional set of techniques using biological processes must be employed next.

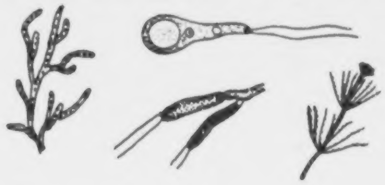
PRIMARY TREATMENT



Secondary Treatment:

Biology at Work

Wastewater flowing out of primary treatment still contains some suspended solids and other solids that are dissolved in the water. In a natural stream, such substances are a source of food for protozoa, fungi, algae and hundreds of varieties of bacteria. The secondary treatment stage is a highly controlled artificial environment in which these same microscopic organisms are allowed to work as fast and efficiently as they can. The microorganisms biologically convert the dissolved solids in the wastewater to suspended solids which will physically settle out at the end of secondary treatment.



Many types of microorganisms work together in secondary treatment to consume wastes present in the water.

There are several different ways to optimize biological conversion. Secondary treatment promotes the growth of millions of microorganisms, bringing them into close contact with the wastewater on which they feed. Care is taken to make sure that the temperature, oxygen level, and contact time support rapid and complete consumption of the dissolved wastes. The final products are carbon dioxide, water... and more microorganisms. Three widely employed types of secondary treatment are common: activated sludge, trickling filters, and lagoons.

The most common is the activated sludge process. Activated sludge processes are much more tightly controlled than either trickling filters or lagoons. In this form of treatment, wastewater and microorganisms are mixed for a few hours in a large tank by constant aeration and agitation. Once the aeration is complete, the mixture of water and microorganisms flows to a sedimentation tank similar to the one used in primary treatment. The microorganisms and other solids settle to the bottom of the sedimentation tank. Since activated sludge is a continuous process, a portion of the settled solids are circulated back to the beginning of the process to serve as "seed" organisms. The part not needed for "seed" is commonly called secondary sludge and is sent to a sludge digester for further treatment.

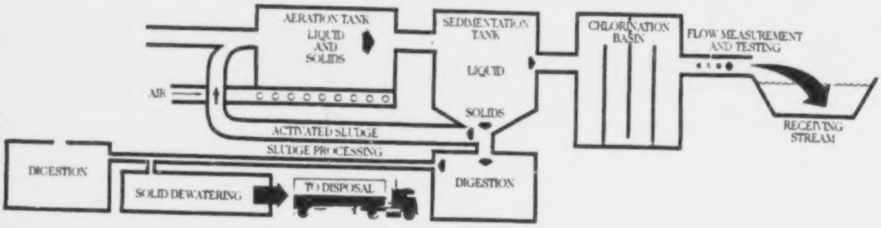
Trickling filters are large beds of coarse, loosely packed material—rocks, wooden slats, or shaped plastic pieces—over which the wastewater is sprayed or spread. The surfaces of the filter material (also known as the "medium") become breeding grounds for the microorganisms that consume the wastes. A common trickling filter is a bed of stones 3 to 10 feet deep. Under the bed, a system of drains collects the treated wastewater and diverts it to a sedimentation tank, or back over the filter medium for additional cleansing. In the sedimentation tank, suspended solids settle and are pumped to a sludge digester. Trickling filters are relatively simple to construct and operate. Many communities in the United States still rely on them for secondary treatment.

Some communities use lagoons to achieve secondary treatment. Lagoons generally treat the total wastewater from a community until the biological oxidation processes have consumed and converted most of the wastes present. This form of treatment depends heavily on the interaction of sunlight, algae, and oxygen. Sometimes the wastewater is aerated to speed the process, since these interactions are relatively slow. There is usually no sedimentation tank associated with a lagoon. Suspended solids settle to the bottom of the lagoon where they remain or are removed every few years. Generally speaking, lagoons are simpler to operate than other forms of secondary treatment, but are less efficient.

At the end of a secondary treatment process, the wastewater is often disinfected to remove disease-causing organisms. Usually, an agent such as chlorine is added to the stream of wastewater before it is discharged to receiving waters. Sometimes other techniques are used if the receiving waters are sensitive to the addition of chlorine.

An alternate to secondary and higher levels of treatment is land application of wastewater. The wastewater is usually sprayed over natural or specially sloped and seeded land. The wastewater seeps into the soil where natural soil microorganisms consume the wastes. The treated water is either used by plants, stays in the ground, or is collected and routed to a receiving stream.

SECONDARY TREATMENT



Sludge Handling: Concentration is the Name of the Game

As the flow of wastewater moves through a treatment plant, various types of solids are removed to restore its purity. Handling those solids can become more expensive and complex than the continuing purification of the main waste stream. Relatively speaking, removing the solids is easy, compared to the effort that goes into handling them once they are taken out.

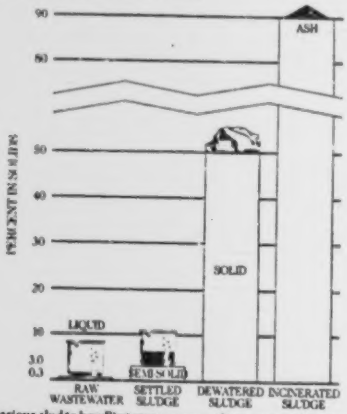
Treatment professionals refer to solids in general as sludge. But these solutions are not the thick, mollasses-like substances that most people think of when they hear the word "sludge." Wastewater sludges are slurries of water and solids that are roughly 100 times more concentrated than untreated wastewater. That is, they contain about 3 percent solids compared to the .03 percent (or less) concentration of the initial flow into a treatment plant. The various techniques for handling these flows are designed to increase the solids concentration even further, to as much as 50 percent.

As a rule of thumb, higher degrees of wastewater treatment produce larger volumes of sludge. For example, primary treatment usually produces 2,500 to 3,500 gallons of sludge for every 1 million gallons of wastewater. Secondary treatment usually produces 15,000 to 25,000 gallons for every 1 million gallons treated. To try to dispose of or recycle such volumes of waste is impractical. Thus sludge handling methods are designed to remove as much water from the mixture as possible.

The spectrum of sludge handling techniques is divided into processes that condition, thicken, stabilize, and dewater the sludge flow. Conditioning operations usually employ chemicals or heat to make the sludge release water more easily. Thickening techniques use gravity, vacuums, flotation, or centrifugal force to separate water from the solids. Conditioning and thickening are usually the first steps in handling primary and secondary sludges.

Stabilization converts the organic matter in the sludge so that the solids can be disposed of or used as a soil conditioner without posing a health hazard in the general environment. Sludge stabilization can occur with (aerobic) or without (anaerobic) oxygen in special tanks called digesters. Sometimes chemicals such as lime are used for stabilization.

Dewatering is done by mechanical means. Filters, centrifuges, and presses remove even more water from the sludge. Sludge dewatered by such equipment has the consistency of wet mud and can have a solids concentration of up to 20 percent. Other techniques such as drying beds or special presses can be used to dewater the sludge, producing up to 50 percent solids—about the consistency of dry soil. At the end of a sludge handling process, the concentrated solids can be placed in landfills, incinerated, applied to land, or composted for use as a soil conditioner.



In various sludge handling steps, more and more water is removed to increase the solids concentration and make ultimate disposal more economical.

Plant Management:

Directing a Cast of Many Players

The successful performance of a wastewater treatment facility, be it large or small, requires the support of a large number of people whose contribution may not be readily apparent when visiting the actual treatment facility.

The wastewater treatment facility staff is responsible for treatment of a waste stream whose characteristics can change daily or even hourly according to factors such as the weather or industrial activities. Their challenge is to convert this widely variable incoming flow (influent) into a consistent outgoing flow (effluent)—treated wastewater that is safe for return to the environment.

In addition to producing clean effluent, proper management of the wastewater treatment facility means an economically efficient operation. Such an operation makes the best use of funds generated through local user charges. In addition to operation and maintenance (O&M) costs, sufficient revenue is needed to meet the annual debt service requirements, or mortgage, on the plant facilities. Wastewater treatment plants are complex facilities, requiring substantial sums of money to construct. Few local governments can afford to pay cash for construction, even if they benefit from federal or state construction grants. It is, therefore, necessary to sell bonds or arrange private financing to raise the required local capital. This money is paid back over a number of years.

The plant manager may be seen as the "battlefield commander" in the war on water pollution. It is the plant manager's job to bring together money, manpower, and materials in an efficient manner to accomplish the objectives of the treatment plant—collection, treatment, and ultimate disposal of wastewater in a manner that is safe and legally acceptable. The basic management functions required to carry out these objectives are identical from plant to plant, but vary in scope depending on the size, location, complexity, and condition of the facility.

In a small town, the wastewater plant manager may have direct access to the mayor of the village and may supervise only one or two employees. In a large metropolitan area or sewer district, the wastewater plant manager may be part of a large hierarchy that includes a mayor, public works director, special board or commission, or other officials above him, and another hierarchy of foremen, operators, and maintenance men below.

The plant manager has overall responsibility for many essential support functions. Among the most important are community relations, budgeting, training, maintenance, and plant safety.

Being a good neighbor is an important part of the process. A good community relations program will inform the public about the importance of wastewater treatment and increase public support for water pollution control programs. Community relations can be enhanced through plant open houses, contacts with local news media, and information distributed with customer bills.

Budgets are typically prepared on an annual basis, and include funds for day-to-day operation of the plant as well as maintenance and replacement of equipment. Since local governments cannot operate in the red, user charges must be annually reviewed and adjusted as necessary to keep pace with costs. Plant operation and maintenance typically cost approximately twice as much per year as the annualized capital cost of constructing the treatment facility.

Adequate training of personnel is critical. Generally, on-site training is provided initially by the engineering firm that designed the plant and by equipment manufacturers. Subsequent training becomes the responsibility of the treatment facility staff. In a large facility, a separate training department may be established.

In almost all states, state certification or licensure is required for individuals who operate wastewater treatment facilities. Such licenses can be obtained only after formal training and passage of a comprehensive exam.

Equipment maintenance is critical to the continued successful operation of a wastewater treatment plant. Plants generally do not fail to perform because of poor operation, but, rather, because of lack of proper maintenance. Adequate maintenance personnel and programs ensure the long-term cost-effectiveness of the facility.

Because the collection and treatment of wastewater is a relatively hazardous occupation, safety consciousness is an essential part of every correctly managed plant. A proper safety program includes regular training in safety and emergency procedures and availability of necessary safety apparatus for all plant and collection system personnel.

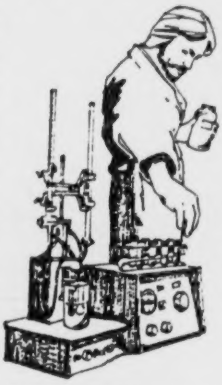
The plant manager is also responsible for many other activities that are part of any large business or industrial operation. These include purchasing, personnel, recruitment, long and short-term planning, and evaluation.

The problems encountered in water pollution control are many and varied and are often unique. Because of this variety of problems, the plant manager and staff must also be innovators. Hard-earned knowledge must be combined with new information to result in a well-run treatment plant.

Monitoring and Permits:
A Constant Flow of Data

When we want to check a person's general health, we may do nothing more complicated than check temperature and pulse. In a typical treatment plant, there are as many as 10 sampling points and 30 laboratory tests by which the "health" of the processes are monitored. Sampling and monitoring usually start at the beginning of the treatment plant as the untreated wastewater flows into the plant. Some sampling is done by hand: bottles are lowered into the flow to collect samples for analysis at a laboratory. Some is automatic: ingenious devices measure the various properties of the flow, reporting electronically to a central information bank. Each of the treatment steps we have described in this booklet has its own sampling and monitoring requirements.

Treatment operators must know what is going on at each stage of the general process so they can adjust the controls to compensate for changes in the composition and behavior of the flow and its contents. Many treatment plants have their own laboratories and in large metropolitan treatment operations these centers are as sophisticated as any used by the medical profession. Mini- and micro-computers are frequently employed to store, retrieve, and evaluate the data obtained in a monitoring program. Some analytical instruments used in a comprehensive monitoring program can detect traces of substances down to one part of pollutant per billion parts of water or even lower.



Control of a wastewater treatment plant requires many sophisticated laboratory analyses.

Many of the monitoring requirements and pollutant discharge limits are specified in a treatment plant's discharge permit. Since 1972, every treatment plant (and every industrial or commercial facility) that discharges directly to a body of water must have such a permit issued by an approved state agency or by the U.S. Environmental Protection Agency (U.S EPA). Today there are approximately 59,000 permits in force across this country. Of that total, 14,000 are held by municipal treatment plants and 45,000 by industrial plants. The authority for issuing these permits comes from federal law. Many states exercise this authority directly; some allow the U.S. EPA to maintain responsibility. The system under which they are administered is called the National Pollutant Discharge Elimination System, or NPDES for short.

NPDES permits tell the treatment authority how often to sample and report on the quality of its final effluent. Each permit for municipal plants is based on a minimum of secondary treatment plus any additional treatment required to meet the water quality standards of the receiving stream. Permits are valid for a specified period of time, but they can be re-opened at any time if national or state requirements change or if the nature of the plant's waste stream changes significantly.

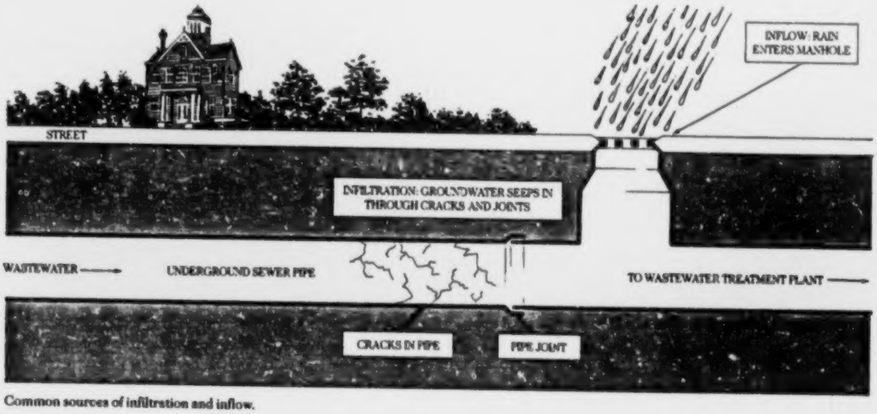
Infiltration and Inflow:
Insidious and Inflationary

Wastewater is delivered to a treatment plant through a system of municipal sewer pipelines. Such systems stretch for hundreds, even thousands of miles, connecting each domestic and industrial customer to the treatment plant at the end of the network. Pipes settle, manholes crack, brick and mortar crumble. Sewer systems are never completely watertight.

In the ideal world, treating the wastewater that comes to a plant through a sewer system is challenge enough. But in the real world, this challenge is made even greater by the intrusion of ground and surface water. This additional water is called inflow when it enters a sewer above ground or from connections with storm sewers. It is called infiltration when it enters the pipes below ground. The term I/I describes this phenomenon. The amount of inflow that enters a system depends on the number of low-lying manhole covers and cross connections within a storm drainage system. The amount of infiltration depends on the number and size of cracks, holes, and leaky joints in the piping system. When it rains, large volumes of I/I can enter the sewer system and can disrupt normal plant operations, lowering treatment efficiency.

It is usually impossible to eliminate all sources of I/I. Federal and state authorities generally agree that up to 20 gallons of I/I per person per day may be a reasonable amount of additional water to process; more than that, and a community must pay a significant amount to treat water it never pollutes. Studies of some systems have found infiltration can add up to 100 gallons per person per day to the normal wastewater flow. Treating the extra water is expensive because more capacity is needed to handle it at the plant. But efforts to correct I/I are sometimes ineffective, and also very expensive.

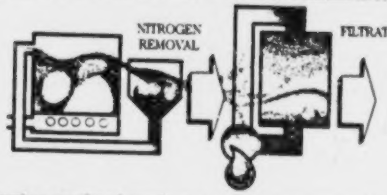
Sometimes 80 percent of the problem can be corrected by repairing 20 percent of the leaks. The trick is to find the right 20 percent. Finding leaks is sometimes harder than fixing them, but fixing them is more expensive. Encouraging advances have been made in I/I detection and some ingenious corrective techniques have been developed recently. Reducing infiltration and inflow saves the treatment authority—and its customers—money.


INFLOW: RAIN ENTERS MANHOLE
STREET
INFILTRATION: GROUNDWATER SEEPS IN THROUGH CRACKS AND JOINTS
WASTEWATER ——▸
UNDERGROUND SEWER PIPE
TO WASTEWATER TREATMENT PLANT ——▸
CRACKS IN PIPE
PIPE JOINT

Common sources of infiltration and inflow.

Advanced Waste Treatment:
Customizing a Plant's Discharge

Every body of water has its own particular characteristics. Each reacts somewhat differently to the discharge of treated wastewater. In most cases, secondary treatment will remove over 85 percent of the biochemical oxygen demand and suspended solids. This is usually sufficient to make the discharge acceptable to the receiving stream. But there are situations where even higher degrees of treatment must be provided. In these instances, the extra processing is known by the general term **advanced waste treatment** or AWT.



Sometimes complex advanced wastewater treatment steps are added to remove specific constituents that remain in the wastewater after primary and secondary treatment.

Advanced waste treatment processes represent one frontier of applied science in water pollution control. Decisions to install AWT processes are not made lightly. Such systems are usually expensive to build and to operate: they normally demand a highly trained operating crew. Sometimes they produce sludges that are difficult to dispose of economically. These techniques can be used, if necessary, to tackle the toughest kinds of wastewater problems. They can produce treated water pure enough to use in industrial processes, to irrigate golf courses and park land, or to replenish groundwater.

Different types of AWT processes are used to remove specific constituents that remain in the wastewater after secondary treatment. In certain cases, AWT systems are designed to remove specific toxic substances that may be present in the waste stream, but generally, the most common types of AWT systems remove nutrients and suspended solids.

Nutrient Removal

All domestic and some industrial wastewaters contain substances which serve as **nutrients**. Discharging too many nutrients can overstimulate the growth of algae and other aquatic vegetation. Excessive plant growth can use so much dissolved oxygen that an insufficient amount remains for fish and other aquatic life.

Thus, some treatment plants must employ AWT processes to remove nutrients. One of the principal nutrients to control is phosphorus. Phosphorus stimulates the growth of algae in surface waters. Typically, phosphorus is removed by adding chemicals to separate it from the wastewater so it can be removed as sludge. Like phosphorus, nitrogen is a nutrient, essential for growth but harmful when discharged in large quantities into lakes or streams. Nitrogen is present in the form of ammonia in domestic wastewater. Primary and secondary treatment usually remove less than half of the ammonia. In the receiving water, ammonia can demand additional oxygen and in some cases be toxic to fish. AWT processes can convert ammonia to another compound, nitrate. This conversion is called **nitrification** and in it, special bacteria change the ammonia to nitrates, a compound that is less harmful to receiving waters.

In some cases a stream is so sensitive to nitrogen that almost all nitrogen must be removed from the wastewater to maintain acceptable water quality. An additional biological process, known as **denitrification**, is employed. Denitrification converts the nitrogen in nitrates to nitrogen gas, a harmless gas which is then released into the atmosphere.

Filtration

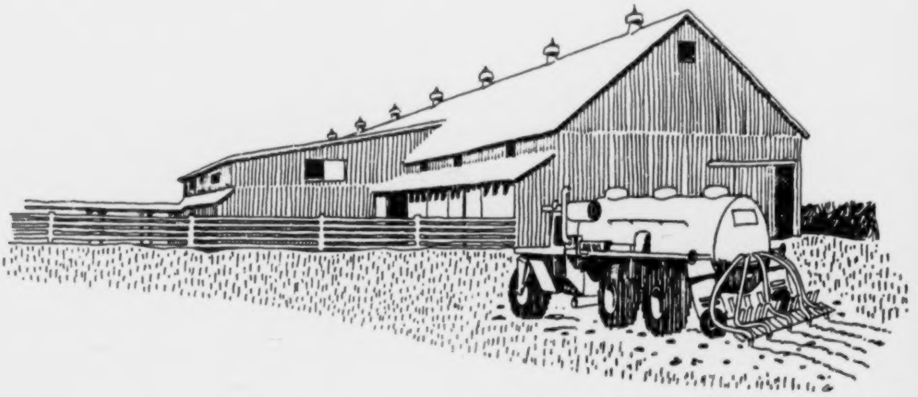
Sometimes it is necessary to achieve a higher level of suspended solids removal than is possible through primary and secondary screening and sedimentation. This is often accomplished by filtration. In this process, wastewater passes through a granular material, such as fine sand or coal. Usually, several types and sizes of filtering materials are mixed together in what is known as a multimedia filter. Eventually, the filter becomes clogged with materials removed from the wastewater. The filter is then cleaned by reversing the wastewater flow in a process known as backwashing.

Sludge Management:
The Challenge is More Than Technical

Long-term disposal or reuse of wastewater treatment sludges remains a difficult goal to achieve. The Law of Conservation dictates that matter can never be created or destroyed. It can only be changed from one form into another. A popularization of that law puts this point even more simply: *Everything must go somewhere*. That is the problem facing many treatment authorities today. Nobody wants to live next to the "somewhere" for municipal sludge. Plans to burn sludge, spread it in the ocean, or distribute it on land abound, but public acceptance is the critical factor in most cases. In the final analysis, an effective, economical sludge management program depends on community awareness of the fact that sludge can have beneficial uses and can be safely disposed of without environmental damage.

One of the foremost beneficial uses of sludge is land application. In this alternative, the organic matter is recycled to the soil. Sludge adds bulk to thin soil, improves water retention, changes acidity, and stops erosion, making some sludges ideal for land reclamation projects. Other sludges with enough nutrients in them can be used to improve the yields of agricultural lands. Still other schemes involve mixing sludge with wood chips, leaves, or shredded paper in a composting operation that creates a product that can be used on lawns, parks, and golf courses.

The most common and oldest method of sludge disposal is burial in a landfill. Another technique used in some areas is ocean disposal, but federal legislation severely restricts this practice. Many municipalities have elected to install incinerators as a means to make disposal easier by changing the sludge into ash. The ash can be disposed of in a landfill.



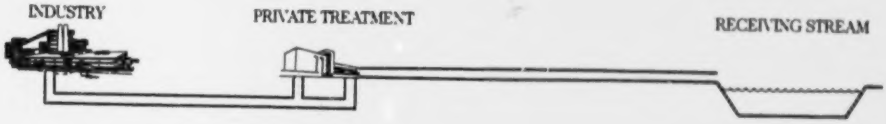
Sludge can have beneficial uses in improving agricultural soil.

Industrial Wastes:
Compatibility is the Key to Effective Treatment

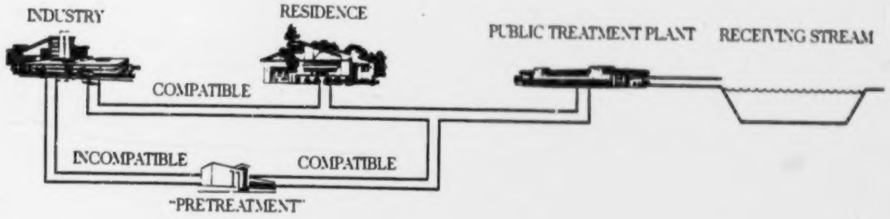
Many industries treat their own wastewater before discharging it to a stream, river, lake, or estuary. In these cases NPDES permits limit what may be discharged. There are approximately 45,000 industrial permit holders. Many other industries rely on publicly owned treatment works (POTW).

Virtually every POTW treats industrial wastewater along with its domestic flows. The term "industrial wastewater" covers discharges from small businesses such as service stations, laundromats, dry cleaners, and restaurants as well as from large installations such as refineries, mills, and food processing plants.

The pollutants in industrial wastewater fall into two groups: those that are basically compatible with municipal treatment and those that are not. A municipal treatment authority charges its industrial customers to treat compatible wastes. For high concentrations of such wastes, a surcharge is usually added. Incompatible substances cannot be discharged to a publicly owned system. Local governments have developed sewer use ordinances that specify which substances are prohibited. Industrial customers can pretreat their wastewater. Pretreatment removes prohibited substances from wastewater before discharge to a municipal sewer system.



Many industries treat their own wastes in private treatment plants.



Other industries send wastes to publicly owned treatment plants.

Glossary

Activated Sludge—is the sludge that results when primary effluent is mixed with bacteria laden sludge and then agitated and aerated to promote biological treatment.

Advanced Waste Treatment—wastewater treatment beyond the secondary or biological stage that includes the removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids.

Aerobic—life or processes that require, or are not destroyed by, the presence of free elemental oxygen.

Anaerobic—life or processes that require, or are not destroyed by, the absence of free elemental oxygen.

Bacteria—unicellular microscopic organisms that perform a variety of biological treatment processes, including biological oxidation, sludge digestion, nitrification, and denitrification.

Biochemical Oxygen Demand (BOD)—a measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution.

Combined Sewer—a sewerage system that carries both sanitary sewage and stormwater runoff.

Denitrification—the anaerobic biological reduction of nitrate nitrogen to nitrogen gas.

Effluent—wastewater, treated or untreated, that flows out of a treatment plant, sewer, or industrial outfall.

Infiltration—entry of water into a sewer system through such sources as defective pipes, pipe joints, connections, or manhole walls.

Inflow—entry of water into a sewer system from sources other than infiltration, such as basement drains, manholes, storm drains, and street washing.

Influent—water, wastewater or other liquid flowing into a reservoir, basin, treatment plant, or treatment process.

Land Application—the recycling, treatment, or disposal of wastewater or wastewater solids by spreading it on land under controlled conditions.

Microorganisms—microscopic organisms, either plant or animal, invisible or barely visible to the naked eye. Examples are algae, bacteria, fungi, protozoa, and viruses.

National Pollution Discharge Elimination System (NPDES)—the permit process established under section 402 of the Clean Water Act.

Nitrification—the oxidation of ammonia nitrogen to nitrate nitrogen in wastewater by biological or chemical reactions.

Nutrients—any substance that is assimilated by organisms and promotes growth; generally applied to nitrogen and phosphorus in wastewater, but also applied to other essential and trace elements.

Operation and Maintenance (O&M)—the organized procedure for causing a piece of equipment or a treatment plant to perform its intended functions and for keeping the equipment or plant in such a condition that it is able to continually and reliably perform its intended function.

POTW—Publicly owned treatment works. The term used in the Clean Water Act to refer to municipal wastewater treatment facilities which are constructed with the help of federal grants.

Permit—a legal document issued by a government agency. In wastewater treatment, a discharge permit requires that the plant operator achieve specific water quality standards and discharge limits by a certain date, and also establishes monitoring and reporting requirements.

Pretreatment—the treatment of industrial wastewater at its source before discharge to municipal collection systems.

Primary Treatment—the first stage in wastewater treatment. Screens and sedimentation tanks are used to remove most material that floats or will settle. Primary treatment results in the removal of a substantial amount of suspended matter but little or no dissolved or colloidal matter.

Receiving Stream—a river, lake, ocean, or other watercourse into which wastewater or treated effluent is discharged.

Sanitary Sewer—a sewerage system that carries only household and commercial wastewater.

Secondary Treatment—generally, a level of treatment that produces removal efficiencies of 85 percent for BOD and suspended solids. Sometimes used interchangeably with the concept of biological wastewater treatment, where waste water is mixed with air and sludge to encourage the growth of bacteria that "eat" organic pollutants.

Sludge—the accumulated solids separated from liquids, such as wastewater, during treatment or processing.

Suspended Solids (SS)—solid pollutants that either float on the surface of, or are suspended in, wastewater. These small particles resist removal by conventional means.

Trickling Filter—a very coarse filter, usually a bed of rocks, used to support bacterial growth and provide secondary treatment of wastewater that is trickled over the rocks.

User Charges—charges made to users of water and wastewater systems for services supplied.

Wastewater—the spent or used water from a community or industry that contains dissolved or suspended matter.

Epilogue

Effective wastewater treatment depends on the participation and support of all sectors of the American public—from Congress to the individual citizen. People are the key to adequate funds for construction, operation, and maintenance of necessary treatment facilities. Competent personnel are needed to operate the sophisticated processes described in this booklet. And state and Federal legislators must ensure water quality goals are attainable through workable, cost-effective regulations. With a clear understanding of the value and needs of adequate wastewater treatment, people can work together to ensure that our national clean water goal is attained.

Ground Water Contamination in the United States

Veronica I. Pye and Ruth Patrick

Ground water that is used by humans consists of subsurface water which occurs in fully saturated soils and geological formations. Nearly half the population of the United States use ground water from wells or springs as their primary source of drinking water (*1*, *2*); 36 percent of the municipal public drinking water supply comes from ground water (*1*); and 75 percent of major U.S. cities depend on ground water for most of their supply (*3*). Total fresh ground water withdrawals in 1980 were estimated as 88.5 billion gallons per day, of which 65 percent were used for irrigated agriculture (*4*). Although ground water contamination has occurred for centuries, increased industrialization, population density, and agricultural activities have greatly exacerbated the problem in some areas. As our dependence on ground water increases, its quality becomes an ever more important issue.

Ground water is not only important to man, it is also an integral part of the hydrologic cycle of the earth—the circulation of water between the oceans, atmosphere, and land. It constitutes approximately 4 percent of the water in the hydrologic cycle, second only to the oceans and seas, which account for about 94 percent (*5*). The volume of ground water in storage exceeds the volume of fresh surface water in lakes, streams, and rivers. Approximately 30 percent of the streamflow of the United States is supplied by ground water emerging as natural springs or other seepage areas (*2*). Ground water forms most, if not all, of the low water flow of streams during dry periods. The interrelation between surface water and ground water is further indicated by the fact that, under certain conditions, surface water may recharge ground water aquifers.

Aquifers may be composed of permeable or porous geological material, either unconsolidated sand and gravel or consolidated material such as carbonate

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rocks, volcanic rocks, or fractured igneous, metamorphic, or sedimentary rocks. Unconfined aquifers are the most susceptible to contamination (Fig. 1). They are not overlain by impermeable material and are recharged by water seeping through the soil. They may be fairly close to the land surface. Water in unconfined aquifers at the saturated-unsaturated interface is at atmospheric pressure and the volume in storage may fluctuate according to seasonal cycles of natural recharge due to precipitation and man's use of the aquifer.

Summary. Ground water contamination is of increasing concern in the United States because about 50 percent of our drinking water comes from well water. The causes of contamination stem from both point sources and nonpoint sources. Since ground water moves slowly, the contaminant may affect only a small portion of an aquifer for a considerable period of time. Deleterious effects on human health have resulted from pathogenic organisms in ground water and from its toxic chemical composition. It is difficult to estimate the extent of contamination on a national basis as the frequency of instances of contamination is very variable. Remedial actions to clean up aquifers are difficult, expensive, and sometimes not feasible. Many of the laws and regulations that control ground water contamination are designed with other main objectives.

Confined aquifers occur at greater depths and are bounded top and bottom by layers of relatively impermeable material called aquitards (Fig. 1). The aquitards and the depth at which they occur offer confined aquifers a certain measure of protection from contamination. Some confined aquifers have no recharge areas and may be considered a finite resource. Confined aquifers may become contaminated when they are tapped for use, when contaminating activities are sited in their recharge areas, or when water of poor quality leaks in from a shallower or deep saline or contaminated aquifer through the aquitards, which are rarely totally impermeable.

Aquifer size is very variable; many are local or regional, whereas others may underlie several states. An example of the latter is the Ogallala in the Midwest. Most occur within 2500 feet of the land surface and may be a few feet or several hundred feet thick. Estimates of ground water in storage in the United States vary from 33 quadrillion gallons (*2*) to 100 quadrillion gallons (*6, 7*).

The water contained in aquifers varies naturally in quality and may or may not be readily retrievable. However, potable ground water occurs in most areas of the United States and can often be used as a raw resource without pretreatment. Such freshwater aquifers are often underlain by deeper saline aquifers. The salinity can depend on the geologic formation through which the ground water passes and the length of time during which it is in contact with a particular deposit in its flow history. There are five types of naturally occurring ground water that often have a total dissolved solids content exceeding 10,000 parts per million. These are connate water, which was trapped in sediments at the time they were deposited; magmatic and geothermal water; intruded seawater; water affected by evapotranspiration; and water affected by salt leaching (*5*). Saline ground water is generally unusable because of its high salinity or the presence of naturally occurring toxic substances. For example, radioactivity from uranium causes problems in Texas, Oklahoma, and New Mexico (*8*). Arsenic may be a local problem in thermal springs (*9*), but it is also a widespread problem, particularly in the western United States.

Sources of Ground Water Contamination

Important sources of contamination include man's activities, such as waste disposal, as well as nonpoint sources. The many sources associated with waste disposal include manufacturing and service industries, agriculture, domestic waste production, and wastes resulting from government activities. Both the number of potential sources and the problems they pose vary greatly. For example, domestic waste production may include such sources as individual sewage disposal systems, land disposal of solid and liquid wastes, and the collection and treatment of municipal wastewater. Industrial activities result in sources such as industrial and other wastewater impoundments, land spreading of sludge, brine disposal associated with the petroleum industry, disposal of mine wastes, and deep well disposal of liquid wastes. Disposal of wastes from animal feedlots may contribute to ground water contamination. In addition, there is the threat posed by disposal of high- and low-level radioactive wastes resulting from a variety of activities, both private and governmental. It is often difficult to state that contamination from a particular source is the result of a particular type of activity. For example, land spreading is a technique used by farmers, municipal authorities, and industry to dispose of wastes. However, all these activities could result in natural or synthetic substances entering the ground water. Some of them are illustrated in Fig. 1.

Other sources of contamination that are direct results of human activities include such diverse events as accidental spills and leaks and the use of highway deicing salts. Agricultural activities, including the application of pesticides and fertilizers, irrigation, and practices resulting in a change in the vegetative land cover, are potential nonpoint sources of ground water pollution. Other sources unrelated to disposal activities include mining, especially dewatering and abandonment, atmospheric contaminants, infiltration from polluted bodies of surface water, and improper well construction. Poorly planned ground water development can, in fact, lead to contamination. Many coastal communities have overpumped their freshwater aquifers and caused saltwater intrusion into the aquifers, rendering the water unfit for many uses.

Factors Affecting the Characteristics of Contamination

The chemical composition of ground water may be influenced by natural processes that are responsible for its background quality. The chemical characteristics of a contaminant may change as it percolates through the soil zone before it reaches the aquifer. Attenuation of contaminants in the soil zone may occur through surface adsorption, dilution, volatilization, mechanical filtration, precipitation, buffering, neutralization, ion exchange, microbial metabolism, and plant uptake. Clay soils have a greater capacity for physicochemical attenuation of contaminants than coarse sands or fissured rocks. Deep soils may contain active organisms whose metabolism results in contaminant attenuation (*10*). Although these changes often reduce the toxicity or mobility of a contaminant, they may not always do so. At present, the biological and physicochemical changes that occur in contaminants in the unsaturated soil zone are not well understood.

Once contaminants reach the aquifer, their attenuation by biological processes is reduced, although there may still be effects due to the physicochemical processes outlined above. Radionuclides have a characteristic rate of decay dependent on their half-lives. In contrast, contaminants such as heavy metals would persist in the ground water if not precipitated or chelated.

Effect of Ground Water Movement on Dispersion of Contaminants

One of the main factors influencing the effect of a contaminant is the slow movement of ground water. Under idealized conditions, transport would result in the formation of an elliptical plume of contamination with well-defined boundaries (*1*), but often this is not the case. The pattern of flow varies in different types of aquifers, and flow rates are governed by hydraulic gradients and aquifer permeability, resulting in a range of values from a fraction of an inch to a few feet per day. The slow movement of contaminants results in a low mixing rate. This factor is important when considering the transport and persistence of contaminants. However, diffusion and dispersion in the aquifer may bring contaminants into contact with geological material that retards their progress and alters their rate of dispersion and thus their potential effect. As ground water moves slowly and the mixing rate is low, the contaminants remain localized over long periods of time and not become as rapidly diluted as they would in a body of surface water. Many contaminants have been found in higher concentrations in ground water than in surface water (*11, 12*).

Problems Posed by Ground Water Contamination

The chemical composition of wastes legally disposed of in landfills or impoundments is usually known. However when the constituents of such wastes interact new compounds may be formed. Many industrial waste disposal practices now involve stabilization of wastes to render them chemically less active; however, leachate production may chemically alter some of the constituents. Thus it is almost impossible to accurately predict precisely what chemicals may reach an aquifer as a result of waste disposal.

The types of contaminant now found in ground water range from simple inorganic ions, such as chloride, nitrate, and heavy metals, to complex synthetic organic chemicals and pathogens such as viruses and bacteria. According to a report to the Committee on Environment and Public Works of the U.S. Senate, requested by Senator Muskie, a study was made of 128 case histories of ground water contamination that resulted in well closings due to the following contaminants: organics, 242; insecticides, 201; chlorides, 26; nitrates, 23; and metals, 619. In the Midwest, nitrate problems are fairly common (*13*). For example, in Washington County, Illinois, 81 percent of 221 dug wells and 34 percent of drilled wells had a nitrogen concentration (as nitrate) of more than 10 mg/liter, the amount known to be toxic to humans (*14*).

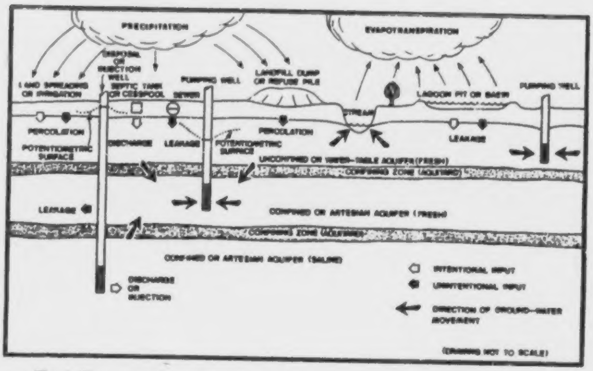

Fig. 1. How waste disposal practices can contaminate the ground water system (*37*).

The deleterious effects of contaminants vary according to the volume of contaminants discharged, their toxicity, their concentration in the aquifer, their persistence through time, and the degree of environmental and human exposure to them. Environmental effects of ground water contamination may include vegetation stress and death, bioconcentration of contaminants in the food chain of the flora and fauna of surface waters, and adverse effects on wildlife and domestic animals that drink from tainted springs. The impact of ground water contamination on humans is difficult to quantify accurately in terms of the number of people affected by well closings. In Nassau and Suffolk counties on Long Island, New York, the wells of 36 communities were closed; these were the source of domestic water for more than 2 million people (*15*). There has been no national survey of the numbers of persons affected by well closings.

Deleterious effects of contaminated ground water on human health are produced by pathogenic organisms or by its toxic chemical characteristics. Between 1945 and 1980 there were 158 outbreaks of disease with more than 31,000 cases of illness attributed to contamination of ground water by pathogenic organisms such as viruses, bacteria, or parasites (*16*). In the same period 57 cases of illness were attributed to occurrences of toxic organic chemicals (*16*). More than 300 cases of illness have been attributed to 20 occurrences of chemical contamination (excluding organic chemicals) (*17*). Outbreaks of illness attributed to waterborne agents are reported to the Centers for Disease Control (CDC) by state health departments; it is thought that only a fraction of those that occur are reported, and the efficiency of reporting varies greatly from region to region. The CDC recognizes that these figures cannot be considered definitive in terms of occurrence and etiology. Reports of the National Academy of Sciences on drinking water and health present data on the effects of ingesting low concentrations of certain chemical contaminants (such as arsenic and chloroform) in drinking water over long periods which are suggestive of links with certain diseases but are by no means conclusive (*14, 18–21*).

Many chemicals now found in ground water have not yet been tested for health effects, and no standards exist for their maximum concentration in water. There has been no national survey of the extent of ground water contamination, probably because well drilling and sampling on such a scale would be extremely expensive and time-consuming. For those reasons, it is not possible to assess quantitatively the risks of ground water contamination. However, it should be emphasized that ground water contamination is often very localized due to the slow movement of the plume; once an incident of contamination is discovered, it does not imply that all the ground water in the area is contaminated.

Table 1. Most frequently reported sources of ground water contamination in the ten states reviewed by the environmental assessment council (*26*); mgd, million gallons per day.

State	Ground water use (mgd)	Natural quality of ground water	Source of contamination	Total number of known contamination incidents	Number affecting or threatening water supply	Number where remedial actions have been undertaken
Arizona	4,800	Generally good; mineralization problems	1. Industrial wastes 2. Landfill leachate 3. Human and animal wastes	23	23	7
California	13,400 to 19,000	Good	1. Saltwater intrusion 2. Nitrates from agricultural practices 3. Brines and other industrial and military wastes	Not known	Not known	Not known
Connecticut	116	Good to excellent	1. Industrial wastes 2. Petroleum products 3. Human and animal wastes	64	38	20
Florida	3,000	Generally good	1. Chlorides from saltwater intrusion and agricultural return flow 2. Industrial wastes 3. Human and animal wastes	92	58	42
Idaho	5,600	Good	1. Human and animal wastes 2. Industrial wastes 3. Radioactive wastes	29	28	13
Illinois	1,000	Generally good	1. Human and animal wastes 2. Landfill leachate 3. Industrial wastes	58	44	35
Nebraska	5,900	Generally good	1. Irrigation and agriculture 2. Human and animal wastes 3. Industrial wastes	35	12	11
New Jersey	790	Generally good	1. Industrial wastes 2. Petroleum products 3. Human and animal wastes	374	198	346
New Mexico	1,500	Fair to good; mineralization problems	1. Oil field brines 2. Human and animal wastes 3. Mine wastes	105	87	27
South Carolina	200	Suitable for most uses	1. Petroleum products 2. Industrial wastes 3. Human and animal wastes	89	66	34

Extent of Ground Water Contamination

Even though no comprehensive national survey of ground water contamination has been undertaken, incidents of contamination have been reported from every state. Assessments completed by the Environmental Protection Agency (EPA) in the 1970's (*8, 9, 22–24*) indicate that problems characteristic of one area may not occur in another, but that several sources of ground water contamination occur at a high or moderate degree of severity in each area studied. The four pollutants most commonly reported—chloride, nitrate, heavy metals, and hydrocarbons—may be a reflection of the monitoring practices prevailing at the time the surveys were made. The problems given priority in the five regions studied were not selected on the basis of statistical information, as it was not available. The priorities were established empirically on the basis of the experience of the authorities and individuals who had worked in the five regions (*25*).

In our studies of the extent and severity of ground water contamination (*26*), we contacted all the states and asked them to provide information on known incidents of contamination. The information we received varied in detail. Some states have computed inventories of known and suspected incidents of contamination; others have just started or are in the process of documentation. We studied ten states in more detail because they had the greatest amounts of information available and also because they served as examples of different levels of industrialization, agricultural activity, population density, dependence on ground water, and climatic conditions. The states chosen were Arizona, California, Connecticut, Florida, Idaho, Illinois, Nebraska, New Jersey, New Mexico, and South Carolina.

The information from these ten states showed that the problems encountered to date vary from one region of the country to another (Table 1). A comprehensive national survey, if undertaken, may find a greater similarity between regions. Human and animal wastes were among the most frequently reported sources of contamination in the ten states listed in Table 1. In California and Florida, saltwater intrusion was the more important source of contamination. The industrial Northeast had problems associated with industrial wastes, petroleum products, and landfill leachate. The agricultural areas of California, Florida, and Nebraska reported problems arising from agricultural practices, and New

Mexico and California reported problems with disposal of oil field brines. The results of these studies showed that the problems depend on the type and degree of industrial and agricultural activities in a region and the population density. The information represents a "best-case" scenario, and the situation could change as new cases of contamination are discovered. The known incidents, depending on the regional or geographic density of the source, may represent single isolated plumes of contamination or many closely spaced plumes, and may fall into geographic patterns.

There have been recent estimates by Lehr (*6*) and by the EPA (*27*) of the extent of ground water contamination nationwide. The EPA (*27*) estimated that about 1 percent of the nation's usable ground water had been contaminated, based on an evaluation of contamination from primary sources (industrial impoundments, municipal and industrial landfills) and secondary sources (subsurface disposal systems, petroleum exploration and mining activities). Lehr (*6*) estimated that the extent of contamination might exceed 2 percent, based on an assumed total of 200,000 point sources of contamination in the country, including septic tanks, landfills, pits, ponds, and lagoons. These estimates cannot be considered complete since they took into account only certain point sources and disregarded nonpoint sources. On a nationwide basis the estimates mean very little, for in some areas reported contamination incidents are very few, whereas in others (more populated areas) they are often much more frequent.

Remedial Action and Aquifer Rehabilitation

When it has been discovered that an aquifer is contaminated, it must be decided what, if any, remedial action to take. Recent studies of remedial action (*28–32*) have concluded that it is complicated, time-consuming, expensive, and often not feasible, and that the best solution to ground water contamination is prevention. The suitability and effectiveness of remedial actions depend on the period over which contamination has taken place, the type and behavior of the contaminants, and the hydrogeology of the site. Often it is more cost-effective to locate a new source of water than to attempt treatment (*28*).

Shallow plumes of contamination in unconsolidated material may be controlled by excavation and removal once the problem of the final disposal method for the contaminated material has been solved. There are two other major categories of remedial actions (*31*): (i) in situ methods and (ii) conventional withdrawal, treatment, and final disposal methods. Many in situ methods are experimental and include detoxification, stabilization, and immobilization. They require the use of biological cultures, chemical reactants, or sealants. The aim is to detoxify or stabilize the contaminants, or to form a barrier around the plume to prevent migration of the contaminants.

Withdrawal, treatment, and final disposal techniques may include the use of one or more of the following: collection wells, subsurface gravity collection drains, impervious grout or slurry curtains and withdrawal wells, and cut off trenches. Methods of water treatment that might be employed include reverse osmosis, ultrafiltration, use of ion exchange resins, ozonation and ultraviolet radiation, coagulation and precipitation, aerobic biological treatment, and filtration through activated charcoal (*31*).

Costs of remedial actions must be estimated on a case-by-case basis as they are influenced by many factors specific to the site. They can range from several thousands to several billions of dollars. For most ground water pollution problems, prevention of contamination would have been preferable to curative actions.

Laws and Regulations Applicable to Ground Water Protection

At present there is no federal program dealing specifically with the problem of ground water contamination. The framework of federal laws that can be used for ground water protection is a group of statutes which are aimed primarily at other environmental problems but which touch indirectly on ground water problems. One of the principal statutes of this type is the Resource Conservation and Recovery Act of 1976, which establishes guidelines for the management of solid and hazardous wastes (*33*). The Safe Drinking Water Act of 1974 contains an underground injection control program to prevent ground water contamination by waste injection wells and to protect sole-source aquifers for drinking water. The Clean Water Act of 1977 requires the EPA to establish, equip, and maintain a water quality surveillance system for ground water as well as surface water. The Toxic Substances Control Act of 1976 and the Surface Mining Control and Reclamation Act both have provisions that could offer a measure of protection to ground water. The Comprehensive Environmental Response, Compensation and Liability Act of 1980 authorizes the federal government to clean up contamination caused by inactive waste disposal sites or spills, many of which pose immediate threats to ground water quality.

These are not the only federal statutes that could be used to protect ground water, but they are the most important ones. They have been unevenly implemented, and as a result they are, at present, not very effective in controlling and preventing ground water contamination.

The states have long been involved with ground water allocation law and water rights, but it is only in the last few years that they have made large efforts to prevent, abate, and monitor ground water pollution. The considerable variation in natural ground water quality and in the quantity used, and the regional characteristics of the major sources of ground water contamination may account for the uneven handling of these problems and the diversity of state regulatory mechanisms and organizational structures.

State regulations that may affect ground water quality fall into three main categories: (i) those dealing with particular sources of pollution such as septic tank systems and waste disposal sites, (ii) those establishing and implementing water quality standards for aquifer water, and (iii) those regulating the use of land in areas overlying critical aquifer recharge zones.

As with federal regulations, the state and local controls that effectively protect ground water often are not designed for that purpose. Even when a regulation is adopted with ground water protection in mind, this may only be one of several regulatory objectives.

EPA Policy on Ground Water Protection

In 1980, after more than a year of discussion and study, EPA proposed a national ground water strategy (*27, 34, 35*). Its goal was to prevent ground water contamination rather than provide remedial action. The suggested approach included the development of state management and protection strategies; the development of a ground water classification system; and EPA coordination of existing federal programs for ground water protection. The proposed strategy was aimed at protecting ground water quality according to its value and use, and the technical approach adopted included the use of siting and design criteria, best management practices, effluent standards, innovative and alternative technologies to achieve performance standards, and, to a lesser extent, numerical ground water quality standards and economic incentives.

In 1981, EPA was questioned by the chairman of the House Government Operations Subcommittee on Environment, Energy and Natural Resources about its lack of action on the proposed national ground water strategy. In response, EPA created two separate ground water task forces, one for policy and one for technical purposes, to develop a consistent agencywide strategy.

The EPA is now revising its ground water policy statement. The statement developed by the two task forces apparently did not resolve inconsistent regulatory issues on ground water protection (*36*) and did not set policies on state classification of ground water. Institutional relations—for example, intrastate and state and local government relations—and EPA commitment to the policy in terms of time and money were not resolved.

Conclusions

The hazards posed by contaminants of ground water vary according to the volume discharged, the toxicity of the compounds, their concentration in the aquifer, their persistence in the environment, and the degree of exposure to them. Ground water forms the base flow of streams, and therefore may contaminate the environment, causing vegetation stress and death, possible concentration of contaminants in the foodchain of surface water organisms, and possible adverse effects on wildlife and domestic animals that drink from tainted springs. The impact on man is difficult to quantify in terms of the population affected by well closings and the numbers of outbreaks of disease and cases of illness. Use of ground water contaminated by pathogens has caused disease outbreaks; there have also been cases of acute public health effects due to chemical contamination of ground water. The effect of long-term use of drinking water with low levels of chemical contamination is not known, and many chemicals now found in ground water have not yet been tested for health effects. The lack of a comprehensive national survey on the extent of ground water contamination and the fact that few contaminants have been tested for their health effects make it impossible to assess in quantitative terms the national risk of drinking contaminated ground water. Many of the data required to assess the severity of ground water contamination simply are not available.

Estimates of the extent of ground water contamination nationwide may not be realistic. The estimates that 1 to 2 percent of our usable surface water may be contaminated took into account only certain point sources and ignored nonpoint sources. Contamination has not been uniform nationwide and in areas of high usage these percentages may be excluded.

One of the major difficulties in dealing with ground water contamination is that it occurs underground, out of sight. The pollution sources are not easily observed, nor are their effects seen until damage, which is often irreversible, has been done. The tangible effects of ground water contamination usually come to light long after the incident causing the contamination occurred and the precise source of contamination may be difficult to determine. Nevertheless, although ground water contamination has occurred throughout the United States and is likely to continue to some extent in the future, we are still in a position to make choices on how best to use, manage, and protect this valuable resource. Prevention of ground water contamination is a more effective strategy than cure.

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II. RESOLVED: THAT THE FEDERAL GOVERNMENT SHOULD IMPLEMENT A NATIONAL SYSTEM OF PRIORITIES TO CONTROL THE ALLOCATION OF ALL WATER IN THE UNITED STATES

THE WATER WARS

From the Missouri River to the Pacific Ocean, Lawyers for Indians, Industries and Inhabitants Are Struggling Over Dwindling Liquid Resources

BY JOHN RILEY

THE BATTLE IS FOR the future — a battle over too many dreams and too little water that threatens to make a shambles of the American West's system of water law.

From the Missouri to the Pacific, in the 17 states where an arcane legal doctrine called "prior appropriation" has allocated Western water's power and wealth for more than a century, lawyers for miners, farmers, Indians and governments are in the midst of a changing historical moment which is testing that system as never before.

Demand is gradually outstripping supply. In state after state, the water bar is grappling with complex new groundwater issues, regulatory schemes and complicated "general adjudications" of conflicting water rights in stream basins. Established water rights are suddenly threatened by environmental and conservationist restraints. Traditions of state hegemony are being tested by grandiose plans for out-of-state water export.

And all those issues are merely lightning bolts and thunder to the West's darkest and most tumultuous legal storm cloud: Indian water-rights claims.

About 60 of those cases, large and small, are already in court. Combined with potential claims in virtually every major Western stream basin, the estimated total — 45 million acre feet annually, equivalent to three times the flow of the Colorado River — could, quite simply, undercut many existing rights and profoundly affect the balance of economic power in the resource-rich West.

That, however, won't happen easily. The tribal claims are being hotly contested in litigation that some compare, in its acrimony and complexity, to a "Civil War battlefield."

In that sense, lawyers agree, the high-

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profile tribal claims merely reflect the pervasive effects of growing Western water conflicts on the legal profession.

"You can't really talk about any activity — real estate, mining, electricity, agriculture — without being concerned about water," says James M. Bush, managing partner at the Phoenix, Ariz.'s Evans, Kitchel & Jenckes, P.C.

"It's an increasingly contentious, difficult field," adds Paul L. Bloom, a prominent Washington, D.C., water lawyer who counsels both public and private clients and law firms lacking water expertise. "The conflicts are increasing, and that's what keeps lawyers' kids in college."

FEW LEGAL RULES are so marbled into the political and social history of a region as the West's "prior appropriation" doctrine.

Eastern water law employed the "riparian" doctrine, which gave owners of land adjoining a water body the right to its shared use — so long as they did not unreasonably interfere with one another — and also gave some protection to water as an environmental resource.

The West was different. It was built around water-intensive industries — mining first, then irrigated farming. Water was short, and both industries required assured, certain supplies for locations that were often distant from the water, rather than supplies subject to future developments by other landowners along a stream.

The catchwords of the doctrine that emerged — "use it or lose it" and "first in time, first in right" — encouraged consumption by providing certainty. The more you used the more you owned, and junior users would be cut off in times of drought.

"The doctrine just flat out ignored any environmental values," adds Prof. Charles F. Wilkinson, an Indian and water law expert currently teaching at the University of Colorado School of Law. "Under prior appropriation, you can just take water out of a stream and drain it."

As the West developed, federal policies encouraged the consumptive philosophy. Federal law deferred to the state doctrines. The federal government left the states to work out their own disputes through interstate water compacts, and encouraged development with massive, subsidized dam, reclamation and irrigation projects.

Now, lawyers say, the hands that fed the West are turning around to bite it.

After a century of stimulating agricultural, industrial and population growth through water projects, the federal spigot is running dry. And, with water supplies already strained, the freewheeling approach of prior appropriation is proving to be a double-edged sword.

Indeed, by most accounts the new tight-water legal landscape in the West is filled with assaults on most of prior appropriation's most sacred themes: certainty and stability, state control and encouragement of consumption.

NOWHERE IS THAT clearer than in the Indian claims fight — an issue that, lawyers say, has made a mockery of stability and certainty.

"We have more than 50 lawsuits that impact on every major water system," says Mr. Bush, who heads an Indian water-rights committee of the Western Regional Council, a consortium of major resource-oriented businesses. "Those lawsuits will result in the slowing down if not the complete frustration of every economic development proposal in the West — Indian and non-Indian — because of uncertainty about who owns what."

"What's new," adds Susan M. Williams, an Indian law specialist with Fried, Frank, Harris Shriver & Kampelman in Washington, D.C., "is that tribes are increasingly aware that they have these rights and are making claims in greater numbers than ever before at exactly the time when development interests are becoming keenly aware of possible shortages. We're in the eye of the storm."

Ironies abound in the history of the claims. In the 1908 case of *Winters v. U.S.*, 207 U.S. 564, the Supreme Court ruled that Indian reservations carried with them a "reserved right" to all water necessary to fulfill the reservation's purpose, and gave the tribal rights a priority date as of the creation of the reservation.

That made them senior and superior to most state-recognized prior-appropriation rights. Moreover, the tribal claims assert, at the same time the federal government should have been protecting Indian water rights in its capacity as "trustee" for the tribes, it instead was using Indian water in the massive reclamation projects that fueled non-Indian Western development.

The result, says Professor Wilkinson, has been a "shadow body of law" clouding the validity of non-Indian water rights throughout the West — and a barely submerged resentment against the federal government on all sides of the fight. "The West ought to be walking hand in hand to Washington and saying, 'You created this problem. Now solve it,' " says Mr. Bush.

Washington hasn't, and the vacuum has been filled with litigation — ranging from damage suits by tribes against non-Indian development interests for past and ongoing misappropriation of their water to a rising number of massive "general adjudications" of all rights in a stream basin initiated by states or private parties to clear up uncertainties.

WHATEVER THEIR form, the cases frequently turn into legal nightmares. One reason is disagreement over the proper forum. Tribes invariably prefer to have their claims heard in federal courts while states and non-Indians press with equal vigor for state court general adjudications. The battles can last for years and the result, says Mr. Bloom, is that "enormous resources are expended over what is essentially a very sterile issue."

In southern Arizona, for example, Indian claims in the Gila and Salt river basin near Phoenix and Tucson exceed all available water, by some estimates, by a factor of three. Those claims spawned one of the nation's largest adjudications, now involving an estimated 80,000 parties.

It began in 1974. But it was just two weeks ago that the Arizona Supreme Court brought jurisdictional wrangling close to an end — subject only to an expected petition for certiorari — by resolving the key remaining issue in favor of a state forum. *U.S. v. Superior Court of the State of Arizona*, 17623-SA.

"We've been fighting over where we're going to fight for 10 years," notes Evans Kitchel's Alvin H. Shrago, who has represented two mining companies, ASARCO Inc. and Phelps Dodge Corp., in the case.

Although recent Supreme Court decisions clearing the way for state court adjudications may limit jurisdictional wrangling in the future, lawyers say, water adjudications promise to remain lengthy. In northern New Mexico's major Indian rights case, *New Mexico v. Aamodt*, CIV 6639-M (D.N.M.), for example, lawyers in the state engineer's office filed in federal court for the express purpose of avoiding a laborious fight over jurisdiction. That was in 1966 — more than 18 years ago.

Part of the problem is their historical complexity. In New Mexico, for example, the status of land and water rights under Spanish colonial administration is a pivotal issue, and the Arizona case involves challenges to 1910 and 1935 decrees agreed to by the Department of Justice on behalf of some Indian tribes.

But observers and participants in Indian claims suits agree that the key cause of delays is uncertainty — both legal and technical — about how to quantify Winters rights.

The clearest standard came in a 1963 case, when the Supreme Court declared that Indians were entitled to all water needed to irrigate the "practicably irrigable acreage" on their reservations. *Arizona v. California*, 343 U.S. 546. And debate over that standard is at the core of the massive tribal claims currently before the courts.

Putting numbers to a standard that is equal parts agricultural economics and hydrological science, lawyers say, usually turns into a costly war of experts that, in the context of a general stream adjudication, is fought between hundreds or thousands of parties with conflicting claims.

"It's like a free-for-all," explains Mr. Shrago.

AND THE COMPLEX technical issues are mirrored by vigorous legal debate over what the Supreme Court actually meant.

One unresolved issue, for example, is whether the water needed to cultivate all "practicably irrigable acreage" is to be measured by today's technology and economic circumstances, or those prevailing on reservations 80 years ago.

Such issues aside, however, lawyers for non-Indians generally acknowledge that if the 1963 standard were "cast in stone," the Indians would have a very strong case.

"Those who really understand the situation understand that the Winters claims are very, very serious," says Jon L. Kyl, a lawyer at Phoenix's Jennings, Strouss and Salmon who represents a major non-Indian water user in the southern Arizona litigation. "And under the Supreme Court's clearest enunciation of the standard to date they would be very substantial. But reality has to filter into this somewhere."

"Reality," to Mr. Kyl and others, means some recognition that the Supreme Court "didn't know how little water there was compared to the number of claims that might be made." And recent Supreme Court cases, while not overturning the old standard, have referred to Indian rights as a "reasonable apportionment" of water necessary to ensure their livelihood.

"My hunch," says Prof. Albert E. Utton, who teaches Indian and water law at the University of New Mexico School of Law, "is that the court is moving from strict adherence to the practicably irrigable standard to a more equitable, balancing approach."

While Indian advocates acknowledge the bad omens, they are a long way from giving up on the Winters claims. "I understand the concerns," says John E. Echohawk, a lawyer and director of the Native American Rights Fund in Boulder, Colo., "because of the growing conservatism of the court. But whether they will actually back down I don't know because it's a very clear precedent, and it's rare that they back down from a precedent."

"We're certainly going to press our claims," adds Rodney T. Lewis, general counsel to the Gila River Indian Community, one of several major tribal claimants in the southern Arizona adjudication. "But the court may change the law."

The uncertainties on all sides of the Indian claims issue have generated considerable talk in the West of negotiated settlements. Many feel that what the Indians really need is "wet water" — the Western term for water that can be used — and that can come only through settlements that would compromise the paper rights in return for federal, state, local and private financial assistance for development projects.

"The needs for wet water and clear title have the potential for bringing people together," says Ms. Williams of Fried Frank, who is currently involved in a negotiation in South Dakota. But the problem, she and others say, is the federal government. Although official policy is to encourage negotiated settlements, lawyers on all sides complain that the policy is not being backed up with money.

One issue is Indian representation. The federal government often has proprietary water claims as a major landowner and fiduciary responsibilities to multiple tribes with competing claims in the same stream basin. As a result, Indians don't trust the Justice Department and the Department of the Interior's Bureau of Indian Affairs to represent their interests effectively.

They say it's almost impossible for them to negotiate intelligently without more funding to hire their own independent lawyers and experts. The government, on the other hand, feels it neither can nor should delegate its trust responsibilities and can't afford to "duplicate" efforts, according to Timothy Vollmann, associate solicitor for Indian affairs at the Interior Department.

But the biggest problem, most agree, is budgetary restraint on money for Indian development projects.

"The Interior Department is steadfastly refusing to put any money on the table," says Randall T. Cox, a Wyoming assistant attorney general who has been trying to work out a settlement of Indian claims in the Big Horn River stream basin. "Their people come to seminars and continuing legal education meetings out here and give great speeches about settlement, but then when we try to put a solution together it's just categorically ruled out."

The result, argues Mr. Bloom, who was an attorney in the state engineer's office when New Mexico filed its Aamodt case in 1966, is "a mammoth Westwide legal gridlock."

WHILE IT ATTRACTS the most attention, the Indian water claims fight is hardly the only major legal battleground in Western water. Another key emerging issue, lawyers agree, is water export. With increasing regularity, proposals to take water from one state and use or sell it in another are challenging prior appropriation's tradition of state control.

"With increased water shortages, it has increased prominence," says Prof. Douglas L. Grant, who teaches water rights at the University of Idaho College of Law.

The area already has seen considerable controversy. A 1982 proposal, now on hold, to use available water from South Dakota in a coal-slurry pipeline to the East raised threats of litigation from downstream states.

A pending application from water-starved El Paso, Texas, to pump groundwater from southeastern New Mexico already has resulted in recent federal court decisions on two different anti-export statutes. And there is growing debate over a private consortium's plan to obtain water rights in Colorado and sell 300,000 to 500,000 acre feet a year to San Diego.

In 1982, the Supreme Court gave impetus to such plans with a ruling that water was an article of interstate commerce. Since then, lawyers say, it has become clear that long-standing "embargo" laws will be struck down, and the fate of subtler restrictions is increasingly unclear.

The trend has states with available water increasingly worried that they won't be able to husband it for their own future needs, and that prior appropriation — untrammeled by export restrictions — will allow the water to be gobbled up by out-of-state markets.

The prospect is not a popular one. In New Mexico, for example, Peter T. White, counsel to the state engineer, contends the El Paso plan will "undermine sovereignty," making his state's economic future a vassal to faster growth and poorer water management in Texas. So far, however, El Paso has had the better of the court battles. *El Paso v. Reynolds*, 80-730 (D. N.M.).

"If you put it in sovereignty terms, it was settled 200 years ago [when the interstate commerce clause was drafted] that you can not allow each state to be sovereign in economic terms," answers El Paso's lawyer, Pieter M. Schenkkan of the Austin, Texas, office of Houston's Vinson & Elkins. "We're going to get the water."

ALTHOUGH INDIAN RIGHTS and interstate export lead almost everyone's list of concerns, anticipated shortages have had broader effects on Western water law and lawyers.

In Arizona, for example, a comprehensive water-management code was adopted in 1980 as a condition for federal funding of the Central Arizona Project, an aqueduct bringing water from the Colorado River to the Tucson and Phoenix areas.

It includes mandatory conservation requirements for water users, notes Kathy Ferris, chief counsel to the state's Department of Water Resources, "and it's those kinds of things that create more need for lawyers."

In Texas, Mr. Schenkkan says shortages are creating "a lot of water-related business, and it's more and more varied." For example, he notes, as water costs have gone up, water rate cases — a mixture of contract law, utility law and water law — are "growing a great deal in importance."

To some, the changes represent the emergence of a conservationist and environmental ethic to challenge the consumptive philosophy that once held sway. "We are seeing an environmental perception of water clashing with the prior appropriation doctrine," says Professor Wilkinson.

He points, for example, to the gradual intrusion of federal environmental laws and policies into water quantity issues, and to a 1983 California Supreme Court case imposing a "public trust," senior to existing prior appropriation rights, to protect the environmental values of watercourses. *National Audubon Society v. Superior Court of Alpine County*, 656 P.2d 709 (1983).

"For people who see other uses than consumptive uses," he says, "it's a central case. The pressures for development are creating scarcity, but so are the pressures for non-development."

Mr. Bloom, who worked for a client on the losing side of the California case, agrees on its importance. "It could have a destabilizing, rippling effect throughout the West," he says. "I would be very surprised if environmental groups don't attempt to use it in other states."

And both men agree, as well, that such cases reflect the broader changes in what was once a narrow specialty.

"Even the nomenclature is changing," says Professor Wilkinson. "The water bar used to include only development lawyers, but now it includes lawyers for environmental groups, Indian tribes, all kinds of different people."

"When you serve notices on 1,000 people in Santa Fe [N.M.] for a general stream adjudication, lots of lawyers start getting questions and sooner or later they get a water practice," adds Mr. Bloom. "And that's what's happening throughout the West."

John E. Echohawk

Mr. Echohawk, a lawyer and director of the Native American Rights Fund, says the Indian water claims will be vigorously pursued but shares the concerns of others that the Supreme Court may be backpedaling on its standards for quantifying Indian water rights. 'Whether they will actually back down I don't know,' he says, 'because it's a very clear precedent and it's rare that they back down from a precedent.'

Charles F. Wilkinson

An Indian law and water law specialist currently teaching at the University of Colorado School of Law, Professor Wilkinson points out that Indian rights is not the only area of conflict in Western water law. A growing environmental ethic, he says, is making the water bar less monochromatic and challenging the consumptive philosophy that has long held sway. 'The pressures for development are creating scarcity, but so are the pressures for non-development,' he explains.

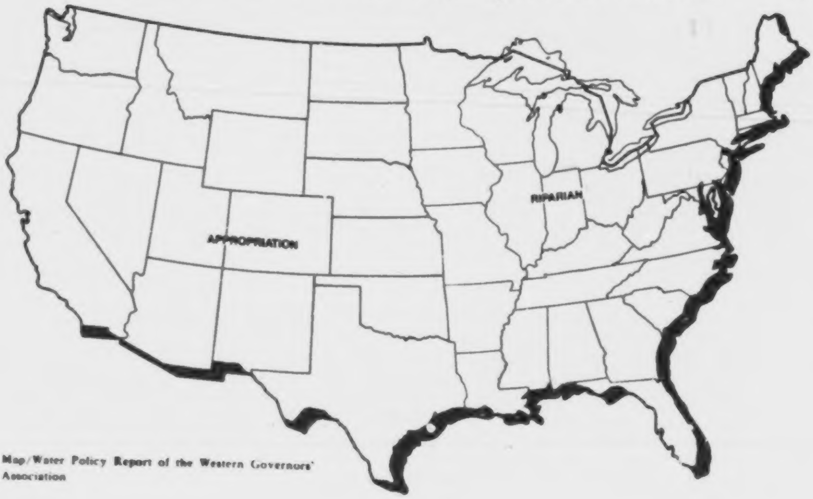
James M. Bush

Mr. Bush, the managing partner at the Phoenix, Ariz., firm of Evans, Kitchel & Jenckes, P.C., heads an Indian water-rights committee of the Western Regional Council, a consortium of major resource-oriented companies. He urges negotiation and says pending lawsuits 'will result in the slowing down if not the complete frustration of every economic development proposal in the West because of uncertainty about who owns what.'

Randall T. Cox

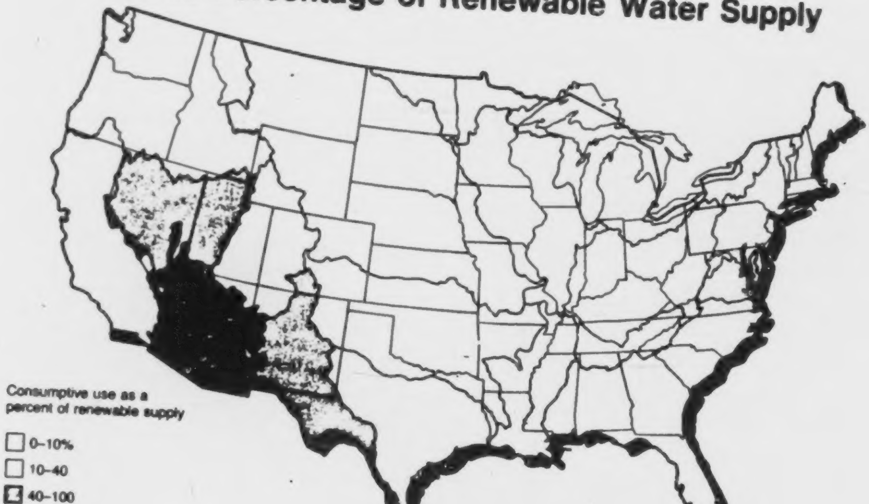
An assistant attorney general in Wyoming who has been trying to work out a settlement of Indian claims in the Big Horn River basin, Mr. Cox's comments are typical of many who say the federal government created the problem and now isn't doing enough to solve it. 'The Interior Department is steadfastly refusing to put any money on the table,' he says. 'Their people come out here and give great speeches about settlement, but then when we try to put a solution together it's just categorically ruled out.'

Riparian and Prior Appropriation States



Map/Water Policy Report of the Western Governors' Association

Use as Percentage of Renewable Water Supply



Map/Water Policy Report of the Western Governors' Association

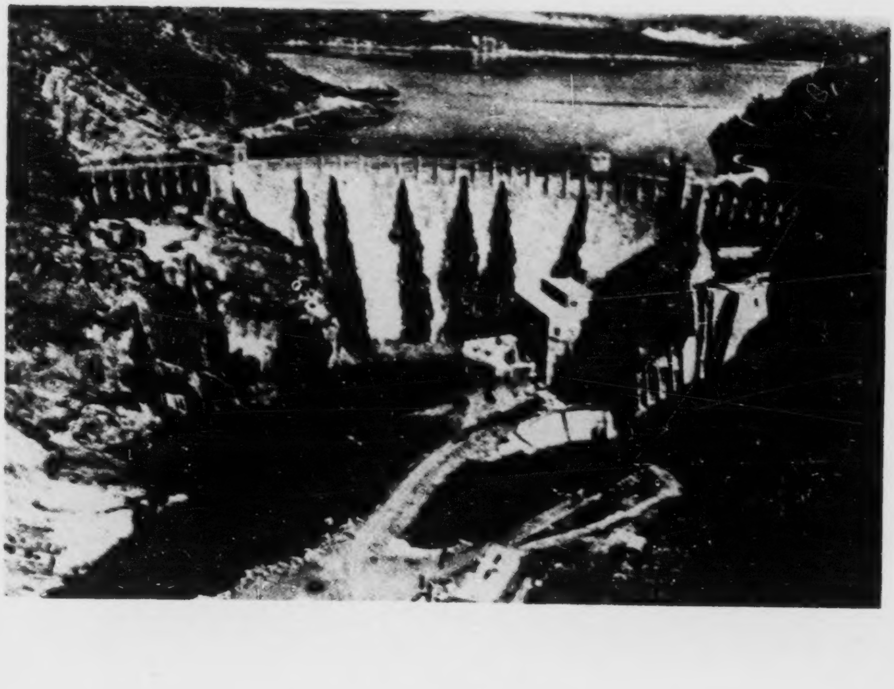
THE THEODORE Roosevelt Dam (right), 80 miles northeast of Phoenix, Ariz., is part of the Salt River Project — a good example, lawyers say, of the massive federal public works that fueled Western growth but now are turning out to be a double-edged sword.

In litigation in southern Arizona that began a decade ago and now encompasses an estimated 80,000 parties in the Salt and Gila river basins, Indian tribes are claiming the federal project used their water as the engine of growth for cities like Phoenix and Tucson.

The litigation is among the most complex in the West, and some speculate it could continue for decades. 'The tensions between Indians and non-Indians are very high, and it would be very difficult to structure a negotiated settlement,' says Rodney T. Lewis, general counsel to the Gila River Indian Community, a major tribal claimant. 'We're committed to following it down to the end.'

'If they think for one minute they're going to get all that water, they're crazy,' answers James M. Bush of Phoenix's Evans, Kitchel & Jenckes, P.C., which represents major mining interests in the region. 'If you granted all the claims and they took the water someplace else, Phoenix would dry up,' adds Salt River Project attorney Jon L. Kyl of Phoenix's Jennings, Strouss and Salmon.

Mr. Lewis faults such 'hysteria.' He says the real fight is future growth, between Indians 'and people from Minnesota who want to retire here.'



WATER RESOURCES, GEOGRAPHY AND LAW

Olen Paul Matthews
Department of Geography
University of Idaho

RESOURCE PUBLICATIONS
IN GEOGRAPHY

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2

Law and Resource Use

Law is an important variable in understanding and explaining the distributional patterns and spatial relationships associated with the use of water resources. The Clean Water Act, the National Enviromental Policy Act, and state water laws have a direct influence on how water resources are used. Other laws do also; sometimes they reflect contradictory policies at the local, state, or federal levels. Because of this, an understanding of the legal system is essential in understanding the way water resources are used. To clarify the relationship between law, society, and resource use, a model has been developed (Figure 3).

The relationship between law and geography has been explored by many authors. Whittlesey (1935, 1939) long ago recognized the impact of the law on the landscape. Today there is a general recognition of the relationship between law and resource management (Fielding 1965; Fitzsimmons 1980; Greenland 1983; Mitchell 1976, 1979). The impact laws have on the location of economic activities, the allocation of resources, and changes in the landscape are matters with which geographers must be concerned.

The Model

There are five principal elements in the model: (1) individual and societal goals; (2) process and structure; (3) legal/political action; (4) formal jurisdiction; and (5) resource field. These elements do not operate alone but are influenced by the bio-physical environment and the behavior of individuals within the system. Also, nonpolitical factors which influence resource use, such as the least cost principle, must be considered in any explanation.

There are several concepts or models in political geography that recognize the legal system as a geographic variable. Whittlesey's law-landscape approach has already been mentioned. Of equal significance to this study is the unified field theory created by Jones (1954) and tested by deBlij and Capone (1969). Jones built upon the ideas of Gottman (1952) and Hartshorne (1950) which concerned the formation and interrelationships of nation-states. The model discussed here is more limited in scope since it deals with water resources only. However, it could be used for other resources. For our discussion, resource "use" incorporates the concept of preservation as well as consumption.

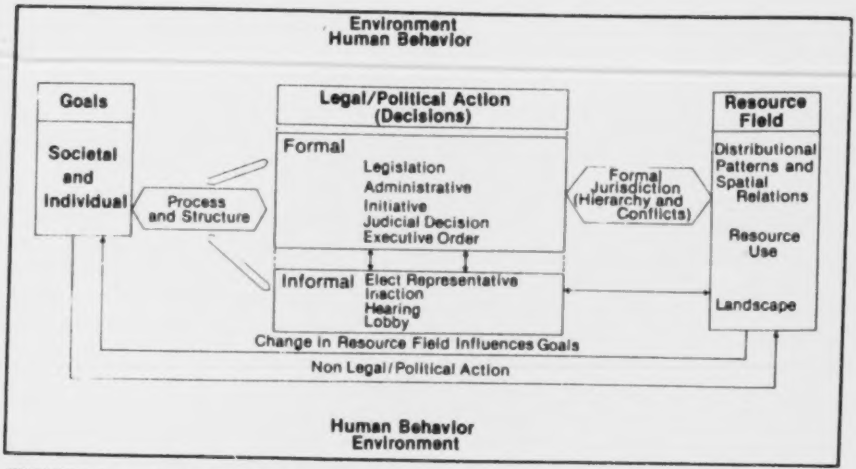

FIGURE 3 RESOURCE LEGAL MODEL

Legal systems are not the same all over the world, as was pointed out by Easterly (1977). The differences limit the use of the model to similar systems. It is also limited to a single country at a time, as most resource mangement and land use planning studies have been in the past (Ackerman *et.al.* 1965). For this reason, the approaches of Gottman and Hartshorne are not as useful as that of Jones, whose idea-area chain can be applied to the internal political functions of a country.

Another major influence in developing the model was Cohen and Rosenthal's (1971) geographic model for political systems analysis. This expands upon the works cited above and upon the systems theory used by Easton (1953, 1965). Although it has been said that "heuristic devices consisting of boxes and arrows seem less exciting than when first discovered," they "provide useful ways of organizing ideas" (Burnett and Taylor 1981). Even if the model presented here goes no further, an organizational tool is necessary to understand the legal system.

Platt's work (1976) which concentrated on land use control at the local level has also been useful because of its emphasis on the legal element. The same is true for Templar's work (1973), which related law to the hydrologic cycle.

Resource management and land use planning were recognized as a major problem area in political geography by Ackerman *et al.* (1965). Kasperson and Minghi (1969) recognized the need for political geography research in environmental problems. Recently Minghi has said this area of research had not blossomed as expected (Minghi 1981). Water resources are part of this research need. The model is an attempt to create, as Jones (1954) said, "a compact description, a clue to explanation, and a tool for better work" so that an understanding of water resources can be obtained.

Goals

The box marked "Goals" in Figure 3 represents the cultural, economic and psychological forces that determine societal and individual goals for water use. This is similar to the "idea" in Jones's idea-area chain and the "societal forces" described by Cohen and Rosenthal (1971). The latter two authors define societal forces as the "ideological influences that concern the organization and goals of the social lives of large aggregations of persons." For Jones (1954) the "idea" is any political idea which allows an individual's actions to be taken into account. This element can also be seen in the policy models discussed by Mitchell (1979).

These goals are not necessarily the goals of the majority, since single individuals or organizations often have the power to go to court and force a change in the way a specific resource is being used. Several court decisions (*Sierra Club v. Morton* 1972; *Sierra Club v. Mason* 1972) have ruled that a club or organization may bring suit on behalf of an injured member. Use of an area for recreational or other purposes by individual members may be all that is needed. If this use is interfered with, "injury" may have occurred. Also, some laws, such as the Clean Air Act (42 U.S.C. §§ 7401-7642, 1983) and the Clean Water Act (33 U.S.C. §§ 1251-1376, 1978), specifically grant individuals the right to bring suit to compel enforcement.

Although most research on the formation and articulation of such goals has been done by scientists other than geographers (Kasperson and Minghi 1969:313-317), Kasperson's (1969) model of municipal stress management is useful in examining the changing goals and values of urban managers. Although managers were specifically analyzed, the model is helpful in this analysis. Other models are discussed by Mitchell (1979).

As conceived here, societal and individual goals are formed by societal forces and individual values interacting with the environment. There is a strong linkage with the "Resource Field." If the perceived world is similar to human goals, the box is static and no change occurs. When individual or societal goals are not satisfied, a need to act arises, which may be satisfied with or without "Legal/Political Action."

For example, the first water users in the West were able to satisfy their desire for water by taking it from a stream and using it. No political action was needed. As more demand was put on this limited resource, the goals of all water users could not be satisfied. Nonpolitical action could be taken, such as bringing water from further away, but this was expensive and required cooperation between individuals. To insure individual rights and to resolve conflicting societal goals, laws were necessary.

The impetus for creating these laws was the California gold rush, where miners found traditional water law inappropriate (McGowen 1956). The result was the legal concept known as the appropriation doctrine, which will be discussed in Chapter 4. Briefly, this doctrine gave a water right to anyone who intended to divert water from a watercourse, actually diverted it, and applied it to a beneficial use. The first person to do this established a priority right which was superior to all rights established afterwards. Today, the appropriation doctrine is generally administered by state agencies who issue permits.

Process and Structure

The kind of political or legal action that can be taken is controlled by existing processes and structures. Political structure at the national level has frequently been discussed by geographers and has often formed a major segment in political geography texts (Norris and Haring 1980; Pounds 1972). Internal political structure has become more important (Bergman 1975; Brunn 1974; Massam 1972; Morrill 1973, 1981; Pearcy 1973; Sauer 1918; Soja 1971) and must be understood before resource use can be explained. Cohen and Rosenthal (1971) recognized this and included a hierarchy of administrative centers within the internal organization of the state.

In the United States four levels in the land use decision process have been recognized: private, local, state, and federal (Platt 1976). This is true for the use of water and other resources as well. If the private sector is excluded, the remaining levels form a hierarchy of overlapping administrative areas. Federal agencies might not control the same subject matter or territory as those at the state and local levels. For example, the Idaho Department of Water Resources, the Idaho Department of Health and Welfare, the Clearwater National Forest, the Environmental Protection Agency, and the Lewiston, Idaho Planning Commission have an interest in controlling the Clearwater River. Neither the subject matter authority nor the goals of these agencies is the same. The territory over which they have authority is also different.

Control over resource use within the United States is divided between the executive, legislative, and judicial branches of the government. All three branches exist at federal, state, and local levels with overlapping authority over the same territory. The court structure will be used to illustrate this point. For example, the Federal District Court for Idaho has jurisdiction over the same territory as the Supreme Court of the State of Idaho but not over the same subject matter. A local court has jurisdiction over a limited area, but this jurisdiction is not exclusive since the state supreme court and federal district court may also have authority. In some instances a specific lawsuit affecting resource use could be brought in either a federal or a state court. Interestingly, once a case is in court, legal issues related to the decision will be resolved even if they are ones usually decided by another court.

The United States Supreme Court has jurisdiction over all territory in the United States (Wright 1976). Beneath it are the twelve courts of appeals (circuit courts) which have regional jurisdiction as is seen in Figure 4. Federal district courts can control an area the size of a state, although in larger states there may be several districts. Figure 5 shows the division of federal district court jurisdictions.

At the state level, the trial court structure varies considerably, with many courts having limited powers based on such factors as whether the case is civil or criminal in nature, the amount of money involved, or a person's age. These factors determine whether a case is brought in small claims court, juvenile court, probate court, criminal court, or traffic court, for example. Appeal from these courts may go to an intermediate appellate court, a state supreme court, or even the U.S. Supreme Court (*Thompson v. City of Louisville* 1960).

Executive and legislative bodies have similar limitations on the area within which their power may be exercised. At the federal, state, and local levels overlapping authority over territory creates a complex regulatory structure. The structure of these internal administrative areas has been studied by geographers, but more work needs to be done on the conflicts these overlaps create.

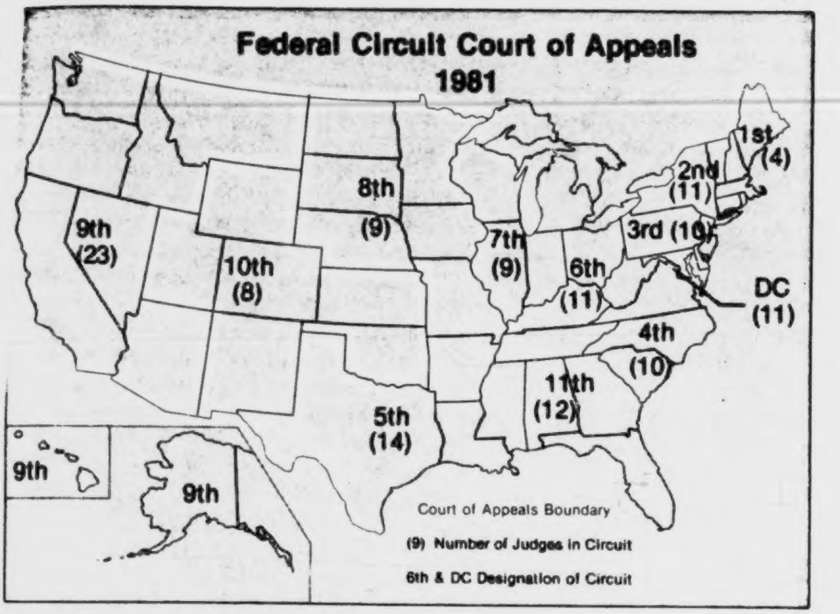
Federal Circuit Court of Appeals
1981
9th
(23)
10th
(8)
8th
(9)
7th
(9)
6th
(11)
1st
(4)
2nd
(11)
3rd (10)
DC
(11)
4th
(10)
11th
(12)
5th
(14)
9th
9th
Court of Appeals Boundary
(9) Number of Judges in Circuit
6th & DC Designation of Circuit

FIGURE 4 CIRCUIT COURT JURISDICTIONS (23 U.S.C. §§ 41 & 44, 1983 supp.)

To achieve the political or legal action desired, the correct functional unit at the proper level of government must be approached. The desire to obtain municipal water services would not usually be satisfied with a letter to a United States Senator or the Bureau of Land Management. The acquisition of water rights is generally controlled by state law, not federal. However, federal law may influence the use and disposal of the water as well as the amount available. The structure of the United States political system is divided into an overlapping series of administrative areas based on function and scale. These administrative areas have boundaries which can be delimited, and for any one spot, many agencies or courts will have power. Within each level of authority different political or legal processes occur which may influence decision making.

"Process" includes the formal procedures and informal processes that must occur in order to obtain a desired "goal" through "political legal action." Formal procedures are those that are required by law while informal processes are other legal political activities that are influential. The differences between the formal institutional arrangements used by society to resolve conflicts and the informal ones are considerable. For example, there is a field of study in law called 'Procedure' which is based on the technical steps necessary to bring a case to court and through the appeal process. Failure to follow proper legal procedure may influence the final outcome. Also, informal processes, such as the demeanor of a witness, influence the final decision.

If a legislative change is desired, there are formal procedures that must be followed to introduce a bill. Whether a bill is made law may also depend on informal processes such as lobbying. A change in legislation could occur by challenging its

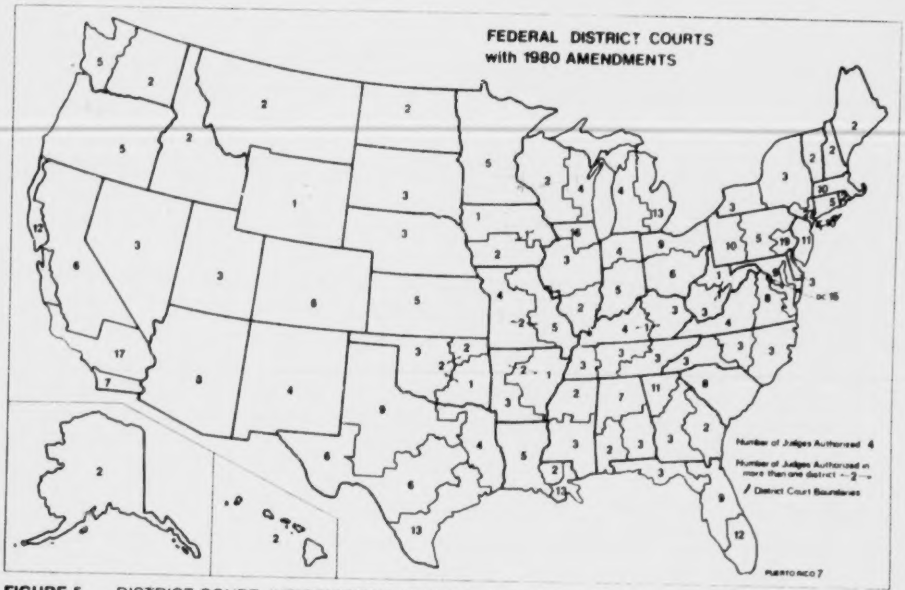
FEDERAL DISTRICT COURTS
with 1980 AMENDMENTS
Number of Judges Authorized 4
Number of Judges Authorized in more than one district ←2→
/ District Court Boundaries
DC 16
PUERTO RICO 7

FIGURE 5 DISTRICT COURT JURISDICTIONS (28 U.S.C. §§ 81-131, 1968 & 1983 supp.)

validity in court. The formal procedures used to change the law are different from those used in introducing a bill, but the results may be the same. Informal processes such as the persuasiveness of an expert witness may be the same in front of a judge or Senate committee. The role of geographers as expert witnesses has been discussed by Mitchell (1978). However, not all informal processes operate in courts and legislative bodies. The influence of a lobbyist on legislators can be considerable, but generally there is no role for them in a court of law. There, the persuasiveness of a lawyer in an adversarial situation forms the basis of the decision.

Ideas or goals do not instantly become laws since formal procedures and informal processes control the activities that occur within the political structure. Although process and structure are developed as a result of societal values, changes in these values are influenced by structure and process, creating a circular relationship.

Although structure and process vary spatially and must be understood by geographers, these elements of the model do not affect resources except through political/legal action, the third major element in the model.

Political/Legal Action

Forms of "political/legal action" (decisions) are listed in the model. Not all political action will influence resource use in the same way. Also, the type of political/legal action will depend on the structure and processes of the political unit that formed the decision as well as individual and societal goals.

If a change in the way water is used is desired, it may be accomplished by formal or informal action. Formal action implements existing law or creates new law through judicial or legislative action. This may take many forms and more than one method may be attempted to resolve an issue. If the legislature fails to change an existing law, it may be challenged in a court on a variety of grounds. The decision by the court is a formal action creating law. Court decisions, congressional legislation, treaties, constitutions, administrative agency rules, city ordinances, and initiatives are laws which result from formal action.

Informal actions are those decisions that do not create laws but may have influence on resources, as is shown by the small arrow in the model between informal action and the resource field. These actions include voting for a representative, administrative activities, lobbying, holding hearings, congressional investigations, or inaction. Informal action may influence resource use through persuasion rather than compulsion. For example, a Senate hearing on a resource issue may point to problems that are voluntarily corrected. An agency's interpretation of existing regulations may carry weight, but may not be binding since it can be challenged in a court. The informal action may be a vote on a bill which does not succeed in creating a law. This may change the way resources are used because resource managers could be influenced to change their policies even though the law did not pass. The decision to do nothing or to change nothing must also be accepted as political action. The failure of a bill to pass is a decision which indicates that no change in resource use is desired or that there is insufficient support for change at that time.

Informal actions may eventually result in formal action. An example of this is the election of representatives to serve in legislative bodies. This is informal because no law is created. The action — voting — results in the election of a representative who becomes part of the political structure with the power to participate in formal decision making.

An election may influence the resource field without any formal action. For example, the 1980 election of President Reagan signified a change in philosophy toward resource use. Changes in the resource field have occurred without formal political action being taken. This can be seen in the political philosophy of a Secretary of the Interior which influences the way decisions are made at the lower levels within his department. Changes in the way public lands are managed result from informal actions taken by the Secretary.

There is considerable geographic research on the linkage between informal political actions and the structure and process within a political system. Most of this has been within the broad study of electoral geography. The structure of voting districts has been addressed in articles on gerrymandering and on redistricting (Morrill 1981). Electoral districts are part of the political structure, and voter decisions in them have been examined (Cox 1968; Gudgin & Taylor 1979; Johnston 1979, 1980a; Lewis 1965; Minghi and Rujley 1978; O'Loughlin 1980; Prescott 1959b; Roberts and Rummage 1965; Taylor and Johnston 1979; Wolfe and Burghardt 1978). Other informal decisions have not, perhaps because of the difficulties in collecting information and evaluating it. Although there is some research in geography on formal political actions (Beard 1975; Fitzsimmons 1980; King 1978; Martin 1930; Thorton and Koepke 1981), there is room for more research in this area since the variation in existing laws is important in understanding variations in human activities.

There are two basic kinds of law in common law countries like the United States — legislation and case law. Legislation, broadly defined, consists of such things as treaties, executive orders, bills passed by congressional bodies, ordinances passed by city councils, constitutions, as well as administrative and court rules. Case law is made up of the judicial decisions of local, state, federal, and administrative courts (Roalfe 1965).

Case law may affect only a few people in an area, impact the entire population, or change the area's political structure. The Supreme Court decision that established the principle of "one man, one vote" changed the structure of election districts (*Reynolds v. Sims* 1964). For this reason the model shows an arrow from formal political action to political process and structure. Also, the Supreme Court has at times established societal goals based on its interpretation of the constitution. The Supreme Court in *Brown v. Board of Education* (1954) held segregation violated the equal protection clause of the constitution. Although this decision did not immediately change the philosophy of society, integration became the only acceptable goal short of amending the Constitution. Since the Constitution of the United States is supreme (Article VI), it supersedes all contrary laws.

Often times the language in a statute is not clear. When this happens the courts may be asked for an interpretation. If the interpretation does not reflect legislative intent, the statute may be amended. However, even if it does reflect the intent of the legislative body, significant societal pressure against the court decision may result in amendment. For example, the United States Supreme Court's interpretation of the Endangered Species Act literally stopped construction of the Tellico Dam in Tennessee (*TVA v. Hill* 1978). Although a court's interpretation is the final word on the meaning of a law, its ruling may not be the final word on an issue. In regard to the Tellico dam, pressure occurred both from within Congress and from lobbying groups to change the law. The result was the amendment of the Endangered Species Act (16 U.S.C. § 1536, 1983 supp.) and the completion of the Tellico Dam.

Court decisions do not always clarify how the law is to be applied even when the actual statement by the court is clear. Many decisions have established that in the eastern United States the owners of land adjacent to a river have a common right to use its waters as long as the use is reasonable. The law is easy to state, but applying it to a specific situation can be difficult. Reasonableness depends on the trade-offs inherent in each situation. What is a reasonable use in one place may not be in another.

Area of Jurisdiction

In international law, jurisdiction encompasses the rights to both prescribe (create) and to enforce a rule of law (Restatement Second, Foreign Relations Law of the United States, 1965). These two rights may be separate or combined. A country may have the power to prescribe a law but not enforce it. A law may require a country's citizens to file income tax returns, but this law may not be enforceable against a citizen living abroad. A law cannot be enforced if there is no power to prescribe. For example, the United States constitution prohibits laws that would take property without compensation. A law that did this would not be enforceable if it were challenged in a court.

The power of a country to enforce laws is based on territory, nationality, the protection of state interests, and the protection of certain universal interests. Nationality (citizenship) and territory are the most important. The United States can prescribe laws over its citizens anywhere in the world, although they may not be enforceable. Jurisdiction over territory is limited by national boundaries. When dealing with a country like the United States, internal boundaries are important also because of the overlapping hierarchy of political units. Boundaries are part of the structure of a political unit and could be considered in that part of the model as well as under jurisdiction. They are included here because of the importance of territorial jurisdiction to the enforcement of laws.

Geographers have long been interested in boundaries. There is a large body of general literature devoted to them (Hartshorne 1936; Johnson 1917; Jones 1945, 1959). There are studies of internal boundaries (Bowman 1923; Cushing 1920; Martin 1930; Mayer 1964; Prescott 1959a; Thomas 1949, 1952) and international boundaries (Ahmad 1953; Alexander 1953; Deasy 1942; Hartshorne 1933; Hill 1965; House 1959; Jones 1945; MacGrath 1927). Ocean boundaries have also been of particular interest to geographers (Alexander 1967, 1968, 1979; Boggs 1937; Capone & Ryan 1973; Hodgson & Smith 1979; Pearcy 1959; Smith 1981). Many of these works address the issue of the location of boundaries, but few look at the internal conflicts created as a result of overlapping territorial jurisdiction.

The limit of jurisdiction is not always the legal boundary around the political unit. This has been pointed out with regard to international law, but it also happens internally. For example, cities often have the power to declare certain activities a public nuisance within three miles of their boundaries, or they may have the power to veto subdivisions one mile outside of the city limit (Idaho Code § 50-334, 1980). This extraterritorial power is limited to those purposes specified by the state and within the power of the state to grant.

Extraterritorial power can also be asserted at the federal level. Countries may claim jurisdiction over their own citizens no matter where they are located. In the Endangered Species Act (16 U.S.C. § 1538, 1974), all citizens of the United States are prohibited from harming listed species anywhere in the world. If a citizen harms a listed species while in Africa, he may be prosecuted under the provisions of the Act when he returns to United States territory.

Even within the boundary of a political unit there may not be exclusive jurisdiction. For example, any one spot in the United States may be subject to the jurisdiction of local, state, and federal bodies, as is illustrated by Figure 6. Each of these government bodies may have limits on the type of power they have within a given territory. For example, federal courts do not usually have subject matter jurisdiction over local criminal violations. The authority of the legislature is limited to those things enumerated in the constitution. When a conflict between state and federal legislation or administrative rules occurs, it is resolved (as shown in Figure 7) in accordance with constitutional principles and grants of authority. This does not mean that federal statutes always supersede state statutes. This occurs only if there is a conflict. If the constitution dictates that state law should control, then it will. Here there is no conflict between the state and federal law because there is no authority for the federal law under the constitution.

Resource Field

The resource field is the area influenced by the political action. This is like Cohen and Rosenthal's (1971) 'political action area' and Jones' (1954) 'field.' The resource field may be larger or smaller than the area over which the political unit has jurisdiction.

The area affected may be smaller than the legal jurisdiction because all land is not treated in the same way. A city might create zones which place unequal restrictions on land use within the city. If the federal government owns land within the city, the city may not regulate it in all ways. Futhermore, the federal government could pass legislation that under the supremacy clause supersedes certain local regulations regardless of the ownership of land. This unequal treatment of resources within a specific political unit may be a policy decision or may result from conflicts between overlapping political units.

Type of Law Level of Authority	Legislation	Administrative Rules	Court Decision
Local	City Ordinance County Code City Charter	Agency Regulation: Zoning Board Building Inspection Etc.	Municipal Court District Court
State	State Statutes State Constitution	Agency Regulation: Dept. of Land Dept. of Water Resources Etc.	State Appellate Court State Supreme Court
Federal	U.S. Constitution U.S. Statutes	Agency Regulation: Dept. of Interior Dept. of Agr. Etc	U.S. District Court U.S. Circuit Court of Appeals U.S. Supreme Court

FIGURE 6 OVERLAPPING JURISDICTIONS

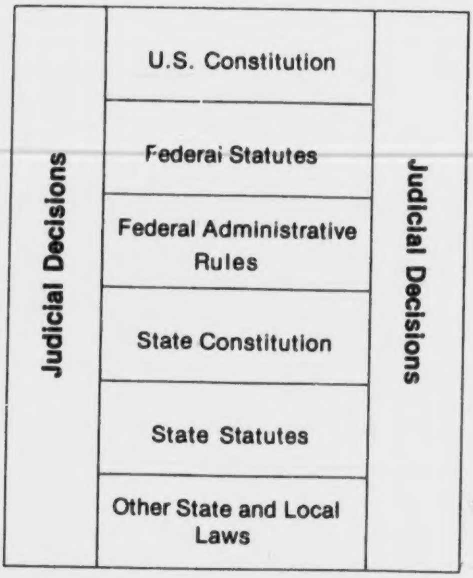

FIGURE 7 CONFLICT OF LAWS

Political action may influence the use of resources outside the area over which the governing body has jurisdiction. A new law which subsidizes agricultural commodities that are normally imported may influence distributional patterns and spatial relationships outside the political unit. Cohen and Rosenthal (1971) distinguish between political action areas and political areas. In their model the political area is the area of jurisdiction and the political action area is similar to the resource field.

The results of legal/political action on the resource field can be divided into three types. One is the effect on the landscape. This has a long history in geographic literature and is usually limited to visible impacts (Christopher 1971; Fuller 1976; Hornbeck 1979; Pattison 1957; Pryde 1976; Rice 1978; and Whittlesey 1935). It includes land ownership patterns, architectural design controls, and the reclamation of mined land. There are few changes more dramatic than those resulting from the construction of a dam and the opening of newly irrigated farm land. The Homestead Act (30 U.S.C. § § 1201-1328, 1971 supp.), the Reclamation Act (43 U.S.C. § § 371-615, 1964) and the Louisiana constitutional provision preserving the French Quarter in New Orleans (Art.14 sec. 221) are examples of laws that impact the landscape.

Specific effects on the landscape are usually limited to the area of jurisdiction of the political unit. However, since landscape features may be slow to change, they may continue to exist long after the boundary or the law has changed. This has long been known at the national level (Whittlesey 1935), but it also exists at the local level. When zones are created that exclude certain pre-existing activities, newly prohibited uses may continue as nonconforming uses with a limited form of legal protection. Also, reclamation laws in a state may only apply to future mining activities. Existing landscape features that resulted from past mining may persist for an indefinite period.

The distributional patterns and spatial relationships of resources are also affected by legal actions. These patterns and relationships are defined by Cohen and Rosenthal (1971:30) as "existing pathways that the distribution of a phenomenon takes from place to place(s), and to the linkages in space that the distributed phenomenon has with pertinent related phenomena." Tariffs, food import restrictions, and severance taxes are examples of laws that influence linkages outside the formal jurisdiction of a political unit. The interstate highway system — the result of a law — changed the internal patterns and linkages in resource use. At the local level zoning laws control land use and transportation (King 1978; Pryde 1976; Platt 1976). Subsidizing water projects for agricultural uses affects the pattern of water use that would exist under a free market economy. Governmental action to enchance or inhibit interbasin water transfers is also a factor (Loeffler 1970; Quinn 1968).

The use of the resource itself can be directly controlled by political action. This is easy to see with local land use controls. Also, it can be observed in water use. The federal government passed the Clean Water Act with the goal of zero pollution. Western states have passed statutes which control the consumptive use of water and regulate the uses to which water may be put. Local governments, trying to conserve water during droughts, have required that lawn watering be curtailed.

Changes in the resource field have an effect on society. Clean water and clean air are expensive, and as a result, the cost of goods can increase. Some industries say this is the reason for plant closures and unemployment. Whether this is true or not, it creates a force in society which can form goals that are anti-regulatory. These goals can be articulated and may become part of the political process. Political action may be taken which will result in a change in law, which in turn will result in a change in the resource field.

The remainder of this book will be devoted to the laws controlling a shared resource — surface water.

4

The Allocation of Water Rights

Because there is a high demand for surface water, it has become necessary for society to develop a system to allocate water rights. State laws may control allocation, but individuals may own surface water outside the normal state system. Municipalities may have the same rights as individuals, but a city's right may be expanded as the city grows, whereas an individual's right may be fixed. On top of this are federal rights which may place limits on the other rights. This chapter discusses how water is allocated and how the conflicts between the different parties are resolved.

Private Water and Pueblo Rights

Although most surface water is controlled by a state allocation system, some is considered private property. Because it is difficult to control or regulate, diffused surface water is excluded from some state's systems. Also, for historic reasons some water is considered to belong to specified cities and is not subject to state control.

Diffused Surface Water

Although the hydrologic cycle is usually treated by scientists as a connected system, the law is different for each part. There are two kinds of surface water that have legal significance. One is water in rivers and lakes. The other kind hydrologists refer to as overland flow or surface runoff. This water has landed on the surface but has not infiltrated, evaporated, or reached a river or lake. In legal terms this water is usually referred to as 'diffused surface water' and may not have the same definition a hydrologist would give overland flow.

Since diffused surface water may flow into streams or lakes, anyone who interferes with it may harm existing water rights. This could occur through soil conservation practices which reduce runoff, or by intentionally capturing the water for some other use. In the West, where water shortages and sparse rainfall are common, disputes over such interferences have arisen. If the diffused surface water belongs to the landowner, he could "capture" it and do what he wants with it. If it is controlled by the holder of the stream water rights, no interference with the flow would be allowed. This might prevent soil conservation measures if it were the accepted rule.

Many court cases say diffused surface water belongs to the surface owner until it reaches a stream and thus is outside the allocation system. *State v. Hiber* (1935), as mentioned in Chapter 1, is a good example of this. In this case Mr. Hiber prevented diffused surface water from flowing onto another's land. Since he was considered the owner of the water by the Wyoming Supreme Court he had a right to do this. Other cases that define a stream's extent concur (*Maricopa County, etc., v. Southwest Cotton Co.* 1931; *Tierney v. Yakima County* 1925; *LeMunyon v. Gallitin Valley Ry. Co.* 1921; *Hutchinson v. Watson Slough Ditch Co.* 1909; *Simmons v. Winters* 1891; *Lux v. Haggin* 1886).

In some western states, water subject to state control is defined by statute or constitution. In North Dakota (No. Dak. Cent. Code § 61-01-01, 1960) and Arizona (Ariz. Rev. Stat. § 45-101 (6), 1983 supp.) diffused surface waters are excluded from the definition of water. In Colorado (Colo. Const. Art. 16, § 5) only "natural" streams are subject to state law, and in New Mexico (N. Mex. Const. art 16, § 2) the state controls "every natural stream, perennial or torrential."

On the other hand, Nevada (Nev. Rev. Stat. § 533.025, 1978), Oregon (Ore. Com. Rev. Stat. § 537.110, 1981) and Utah (Utah Code Ann. § 73-1-1, 1980) statutes say that state law controls all water. There are several Utah cases that interpret this to include diffused surface water (*McNaughton v. Eaton* 1952; *Riordan v. Westwood* 1949). Concurring in one opinion a justice includes rain and snow as public water regardless of where it falls. Public ownership would start from the moment the moisture strikes land. In Montana (Mont. Rev. Code § 85-2-103, 1983) diffused surface water is specifically included under public waters.

If diffused surface water is owned by the landowner, what happens when an entire watershed is owned? Oklahoma City owned almost all the land in the East Elm Creek watershed. When it built a dam the city claimed ownership of all the water that flowed into the reservoir. It said it had only captured diffused surface water which belonged to it. The Oklahoma Supreme Court held (*Oklahoma Water Res. Bd. v. Central Okl. Master Conservancy Dist.* 1969) that the city had not captured diffused surface water since the water had been in a river before the dam was built. Once water is in a river or lake it is subject to the control of state law. State law generally treats lakes the same as streams. However, when does water become part of a stream?

Bed, Banks, and Flow

In general, a river or water course has a channel with a bed and banks. Also, it has a current or reasonably regular flow of water. This may be easy to state, but what about a braided stream — does it have banks? What about stream channels that have water in them only two or three times a year after a heavy rain? What about a stream that disappears underground and reappears as a spring? Is it in a channel with bed and banks while it is underground?

When the bed and banks are clearly visible, their existence is generally accepted. Draws or swales do serve as routes for water drainage, but they are not necessarily water courses in a legal sense. Vegetation must be considered. If an area is entirely grass covered, this weighs against its being a water course. If it can be crossed easily in a vehicle because it has no banks, this must also be considered (*State v. Hiber* 1935). Since the bed and banks are visible features, this often can be resolved easily. However, there are exceptions.

Medano Creek in Colorado disappears into some sand hills near Zapato. Three and seven miles west of where it goes underground two springs appear. In 1902 two people began using water from the creek, and the flow in the springs was reduced. Prior appropriators of the spring water, who could no longer get their full appropriation, sued those taking water from the creek. Can underground water be a water course subject to state law since it is moving under the surface through sand? The Colorado Supreme Court held (*Medano Ditch Co. v. Adams* 1902) that even though no channel was visible, it was well defined and known. Therefore, no interference was allowed with the appropriated rights.

Other cases have been concerned with the current or flow of a stream. In *Turner v. James Canal Co.* (1909) the California Supreme Court ruled that it did not matter if the water in Fresno slough flowed north sometimes and south at other times. Even though streams do not normally act in this manner, the court felt the slough should be considered the same as any other water course.

Another legal concern has been the regularity or the amount of flow. In Texas, Barilla Creek typically flows less than twenty times each year depending on the number of rains. There is water in the creek only a few days after each rain. The bank is three to fifteen feet deep, and the bed is forty to one hundred feet wide. A dam was proposed which could control 350 square miles of the watershed. This would prevent any water from reaching a down-channel land owner. In the lawsuit that followed, the court used a functional rather than a descriptive analysis. Since it was practicable to use the water for irrigation, it was subject to state law (*Hoefs v. Short* 1925). If this same test were used for diffused surface water, its capture would cause it to come under state control.

The interpretation of bed, banks, and flow can be descriptive or functional. If the bed, banks, and flow are obvious, then disputes over whether a stream exists are not likely to occur. Where they are not obvious, courts may use a functional analysis. If the water can be put to a beneficial use, such as irrigation, state law should control its allocation. However, if the water has not yet reached a water course, it may be considered private water.

Pueblo Rights

Most states grant water rights to cities under state law. As a city grows these rights can be expanded by condemning existing rights. Some cities with pueblo water rights can expand their use of water without compensating the person from whom the right was taken. This right, like the right to diffused surface water, is outside the control of the state.

In the Southwest some cities have been recognized as having water rights which date from the time of Spanish or Mexican control (Clark 1960; Gleason 1977; Hoffman 1981a; Hutchins 1960; Kahrl 1982; Kinney 1912; Ostrom 1953). Agricultural villages (pueblos) founded by the Spanish or Mexican government are different from other cities in the United States. They were not given a local charter and were subject to the control of the central government. The first of these pueblos was established by the King of Spain with a special ordinance. The Pueblo of Pictic (Pitic) in Sonora, Mexico was given the right to use the water flowing through the town. This water right was granted to all pueblos subsequently founded. Although these pueblos were granted water rights before they were part of the United States, these rights were recognized by the United States in the Treaty of Guadalupe Hidalgo and by the Gadsden Purchase.

The pueblo water right can be enlarged as a city grows in either population or area. If a boundary expansion takes in new water sources these may become subject to the city's control. Although this water right is not a significant issue in most places, the California courts have granted it to Los Angeles and San Diego (*City of San Diego v. Cuyamaca Water Co.* 1930). In Los Angeles the city has a right to all the water in the Los Angeles River and the ground water that is connected to it. As long as the water is used for municipal purposes the right can lay dormant and then be activated when need arises. This has caused conflict between Los Angeles and neighboring cities which has resulted in litigation (*City of Los Angeles v. City of San Fernando* 1975; *City of Los Angeles v. City of Glendale* 1943). Conflicts have also arisen between Los Angeles and individual water users (*City of Los Angeles v. Los Angeles Farming and Milling Co.* 1908; *City of Los Angeles v. Hunter* 1909; *City of Los Angeles v. Pomoroy* 1899; *Vernon Irrigation Co. v. City of Los Angeles* 1895; *Feliz v. City of Los Angeles* 1881; *City of Los Angeles v. Baldwin* 1879).

The only case outside of California that grants pueblo water rights is *Cartwright v. Public Service Co. of New Mexico* (1958). This New Mexico decision granted Las Vegas, New Mexico, a priority in the use of the Gallinas River. It was awarded a right to as much water as needed for municipal purposes. Several other New Mexico cases mention pueblo rights, but no others have been recognized (*Albuquerque v. Reynolds* 1963; *New Mexico Products Co. v. New Mexico Power Co.* 1937; *State v. Tularosa Community Ditch* 1914).

State Rights

Water is a renewable resource. Thus a state allocation system controls the right to take it and use it over a period of time (Trelease 1979). Water use is controlled by laws which have been developed to encourage desirable human activities and hinder undesirable conduct. Since each state has had the power to regulate water use and create water rights, fifty different state water laws have evolved (Figure 10). Similar physical conditions in the West resulted in the evolution of laws based on a common principle — first in time, first in right. In the East, the English common law riparian rights system was adopted. In a few states both doctrines are used. Differences between state's systems may be blurring with time, however, as many systems have similar aspects (Meyers and Tarlock 1980:196).

The Appropriation Doctrine

Prior to 1850 there was no appropriation doctrine in the United States. Water law was based on the inherited common laws of England. Water rights were recognized in those who owned land adjacent to a river (riparian rights) or lake (littoral rights). Water could be used on adjacent land but not elsewhere. This doctrine worked in the East but was unsuited for conditions in the West; here mineral development provided the need and opportunity for change.

The discovery of gold in 1848 set off a migration which increased California's population from two or three thousand to two or three hundred thousand in a few years (McGowen 1956). Gold was the attraction, but there was no system to control its allocation. The miners were, in fact, trespassers on the public domain (Trelease 1971). It was not until 1866 that the United States passed legislation authorizing their activities

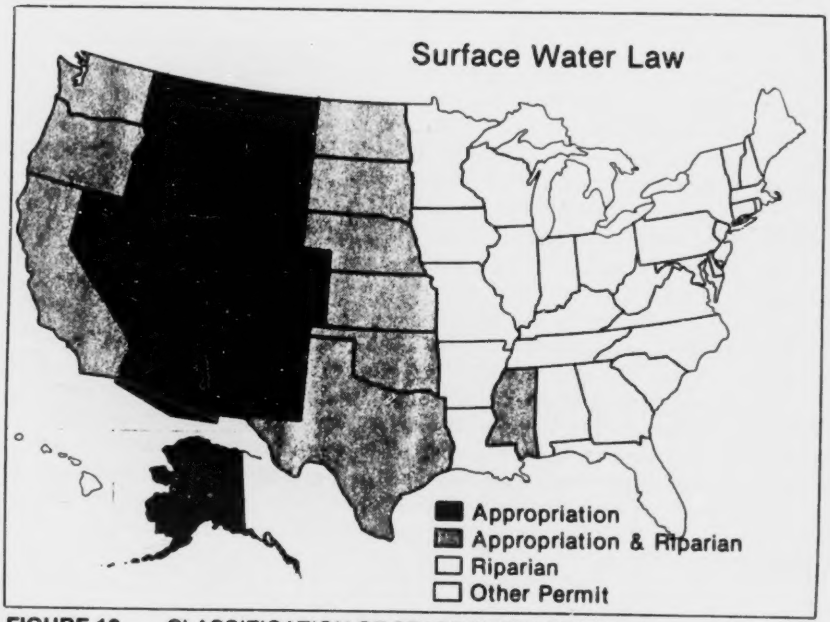

FIGURE 10 CLASSIFICATION OF STATE SURFACE WATER LAWS (Ausness 1977, 1983; Meyers and Tarlock 1980; Aka. Stats. §46.15.040 1977)

(14 Stat. §§ 251 & 253). As a result the miners themselves had to develop a system that would control resource allocation.

When gold was discovered in an area and the rush to that place began, a mining district would be organized to provide a governing body. Although these bodies varied in complexity, there were certain characteristics common to all. Since much of the districts' function was to prevent conflicts between miners, all developed a set of mining laws. This usually put a limit on the size of each claim, required it to be staked, and provided a register so the claim could be recorded. One of the most important concepts was based on the idea of first in time, first in right. The person who found gold had the right to it above all others, unless the claim was abandoned by failure to work it. This was the basic law adopted by the United States and formed the basis for allocating another essential western resource — water.

The first case accepting the appropriation doctrine was *Irwin v. Phillips* (1855). Water was needed to work the placer deposits first developed in the California gold fields. Some miners had diverted water from a stream to their diggings some distance away. Latecomers staked claims on the streambed and wanted the water returned to its natural channel for their use. The eastern riparian rights doctrine which was commonly accepted at that time would not have allowed the diversion. However, it did not give the latecomers rights either. Since riparian rights exist only in those who own land adjacent to a river, how could a trespasser with no right to the land claim he had a right to the water? The California court decided to depart from traditional common law because it did not seem to fit the circumstances. Its decision followed the same principle as was used in allocating mineral rights — first in time, first in right. The "judge made" law that evolved can be summarized:

> *A property right in the use of water is created by diversion of the water from a stream (or lake) and its application to a beneficial use. Water can be used at any location, without regard to the position or place of use in relation to the stream. In the event of a shortage of supply, water will be supplied up to a limit of the right in order of temporal priority; the last man to divert and make use of the stream is the first to have his supply cut off (Meyers 1971:4; footnotes omitted).*

Since the first judicial decision a slow evolutionary process has taken place with a combination of statutes and court decisions controlling the allocation of western water rights. In order to get a water right under the common law appropriation system a person must: (1) intend to appropriate the water; (2) divert it from its channel; and (3) apply it to a beneficial use. To these common law elements most states have added the requirement of a permit. Since a permit application shows 'intent to divert,' this has replaced the need to show 'intent' in establishing new water rights. However, the concept is still of importance in establishing priorities that predate the permit requirement.

The cases concerned with intent have risen out of some peculiar circumstances. The water from Abo Wash, New Mexico, naturally irrigated grass in the area. Cows grazed on the grass and some farmers cut hay. Did the farmers intend to appropriate the water by cutting hay and turning stock loose? A New Mexico court held they did not (*Reynolds v. Miranda* 1972). Often the concept of intent is connected with the idea of 'notice.' Since intent is a frame of mind, courts look to see if there was any open physical act which would show what that intent was. This act should be enough to put others on notice that a water right has been established so time and money are not spent by latecomers (*Elk-Rifle Water Co. v. Templeton* 1971).

The second requirement for an appropriation is the diversion of water from its natural channel. Specific cases include natural overflow situations and instances where animals have been drinking the water. Both of these situations also create 'intent' problems. In Utah, making use of natural overflow is not an appropriation of water (*Hardy v. Beaver County Irrigation Co.* 1924), but in Oregon it is (*In re Water Rights in Silvies River* 1925). Stockwatering appropriations have been frequently upheld (*England v. Ally Ong Hing* 1969; *Stevenson v. Steele 1969; Hunter v. United States* 1967; *Steptoe Livestock Co. v. Gulley* 1931). In Utah, livestock have a right to drink, but no water right is obtained (*Adams v. Portage Irrigation Reservoir Power Co.* 1937).

The diversion requirement may not always be needed today. Part of its purpose was to give notice to others that a water right existed. Today's permit systems do that. Also, requiring a diversion precludes appropriations for instream uses. To get around this problem states have passed special statutes (Colo. Rev. Stat. § 37-92-102, 1982 supp.). The Idaho Supreme Court upheld (*State Dept. of Parks v. Idaho Dept. of Water Administration* 1974) a state statute (I.C. § 67-4307, 1980) that directed the Department of Parks to appropriate all of the unappropriated water in designated springs for instream uses.

The water must also be applied to a 'beneficial use.' Mining, manufacturing, irrigation, stock watering and domestic uses have always been considered beneficial uses, but historically recreation and scenic beauty have been more questionable. The early cases were not very charitable (*Empire Water and Power Co. v. Cascade Town Co.* 1913). In Idaho, recreation and scenery are beneficial if the state is doing the appropriation (*State Dept. of Parks v. Idaho Dept. of Water Administration* 1974). In 1973 Colorado passed a statute that allows the appropriation of minimum stream flows to preserve the natural environment (Colo. Rev. Stat. § 37-92,102, 1982 supp.). Although 'beneficial use' was seldom defined in the past, recent statutory changes are including recreation, aesthetics, and preservation of environmental values (Calif. Ann. Code, Water, § 1243, 1971; Mont. Rev. Code § 95-2-102, 1983; N.D. Cent. Code § 61-04-01.1, 1983 supp; Wash. Rev. Code Ann. § 90-54.020(1), 1983 supp.).

In all the appropriation states except Colorado a permit is required to initiate new surface water rights (Meyers and Tarlock 1980). The permit shows the intent to appropriate water and puts others on notice that water is to be used. Permits will be denied in some states if they are not in the public interest (Alaska Stat. § 46.15.080, 1977 supp.; Cal. Ann. Code, Water § 1255, 1971; N.M. Stat. Ann. § 72-5-8, 1978; Ut. Code Ann. § 73-3-8, 1980). In others an environmental impact statement may be required (Wash. Rev. Code Ann. § 43.21C.035, 1983) or costs and benefits considered before a permit will be issued (Wash. Rev. Code Ann. § 90.54.020 (2), 1983 supp.).

The traditional philosophy with regard to water is ably stated in the novel *Centennial* (Michener 1974:568). The goal of the farmers was to see that the South Platte River left the state dry. This attitude is reflected in the Idaho Constitution (Art 15, sec. 3), which states, "The right to divert and appropriate the unappropriated waters of any natural stream to beneficial uses shall never be denied. . . ." Colorado has a similar provision (Colo. Const. Art XVI, sec. 6). Even with this provision there are some grounds for denial in Idaho, including inadequate water supply, interference with another's rights, bad faith, insufficient funds to complete the project, and conflict with local public interest (I.C. § 42-203, 1983 supp.).

The principle which states that priority in time gives priority in right allows early appropriators who are not getting their full amount of water to shut off later appropriators in inverse order of priority until their water right is satisfied (I.C. § 42-106, 1977; Ut. Code Ann. § 73-3-21, 1980). This may create inefficient results. In parts of the mountain West, ranches were established on the valley floors with later ones going progressively up the side canyons. This means the highest priority rights are the furthest downstream. In order for the downstream ranchers to get the full appropriation to which they are entitled, the upstream users may have to allow the stream water to pass by. This is justified because the first ranchers in the valley spent time, money, and effort in building diversion works and developing ranches. If anyone who came along at a later time could destroy the value of this by taking the water from further upstream, why would a downstream appropriator bother to spend money in the first place?

Under the traditional system, the priority date 'related back' to the date of the first 'open step' representing the commencement of labor on the diversion works, as long as the work proceeded with 'due diligence.' This doctrine of 'relation back' was to encourage major works which would take time to construct. If five years' construction work were necessary before water could be diverted, others could have taken it in the interim. There has been some question about when the first 'open step' which gave notice of intent to appropriate was taken (*Colorado River Water Conservancy District v. Twin Lakes Reservoir and Canal Co.* 1973; *Four Counties Water Users Association v.*

Colorado River Water Conservancy District 1966; *City and County of Denver v. Northern Colorado Water Conservancy District* 1954). Today the permit application is considered the first step and priority dates from then. Due diligence is controlled by statute with time limits for beginning and completing work (Ariz. Rev. Stat. § 45-150, 1983 supp.; Idaho Code § 42-217-204, 1983 supp.; Neb. Rev. Stat. § 46-238, 1978; Nev. Rev. Stat. § 533.390, 1981; N. Mex. Comp. L. § 75-5-8, 1978; S. Dak. Comp. Laws § 46-5-25, 1982 supp.; Wyo. Stat. § 41-4-506, 1977).

The senior appropriator has obligations as well as rights. He is protected by his priority date, but others junior to him are protected by a right to have the continuation of the stream conditions as they existed at the time of their appropriations. Changes in point of diversion, place of use or nature of use could materially injure or adversely affect junior appropriators. Since the same water may be used and reused by several persons, all may have rights that entitle them to receive the same molecules of water. If the sale, change in use, or transfer of water makes those molecules unavailable to another, the first user has destroyed the latter's water right. This makes it difficult to treat water as a disposable property right in some western states. Each state treats the changes allowed to a senior in the use of his water rights differently. In some states it is relatively easy, but in others it is very difficult (Ariz. Rev. Stat. Ann. § 45-172, 1983 supp.; I.C. § 42-108, 1977; Ut. Code Ann. § 73-3-3, 1980).

Another early principle of the appropriation doctrine requires continued used of the water, or else the right is lost. Abandonment of a water right requires the cessation of use plus a 'manifestation of intent' to give up the right. This 'manifestation of intent' could be an act which made it obvious that the right was being abandoned. A formal announcement would be enough as would the destruction of all the workings needed to obtain water. It is often difficult to determine if there is 'intent' to abandon. In one case fifty-four years of non-use was inferred to be enough to show intent (*C.F. & I. Steel Corp. v. Purgatory R. Water Cons. Dist.* 1973). There are many cases on this (*Parsons v. Ft. Morgan Res. & Irr. Co.* 1913; *Featherman v. Hennessy* 1911; *Brockman v. Grand Canal Co.* 1904). Because abandonment has been difficult to prove, many states have passed forfeiture statutes which cause an involuntary termination of a water right after a specified period of non-use (I.C. § 42-222(2), 1977). Although forfeiture and abandonment are sometimes used interchangeably, forfeiture results from statute and the intent of the party is unimportant.

Until permits were required, the only secure way to establish a water right was by court order. This may have resolved disputes between the parties to the litigation, but it left the rights of others on a river system unresolved. The western states have been going through an adjudication process in an attempt to quantify all individual rights on different stream systems (Colo. Rev. Stat. § 37-92-101, 1973). In an adjudication all the conflicting water rights in a water shed are quantified and priority dates assigned. This is a slow process, but necessary. Not only are the water rights of individuals involved, but those of irrigation districts and the federal government as well.

This has been an oversimplified description of the appropriation doctrine. The role of irrigation districts and federal reclamation projects has been left out. Enough has been presented so that the complex litigation and statutes that have evolved can be appreciated. Societal responses to conflicts over a scarce resource vary according to circumstances. Since each state had the power to make allocation decisions, different sets of controls evolved among the states. In the West, laws were a response to aridity and scarcity, but conditions in the East were different.

Riparian Rights

When the United States was settled, English water law was in its early stages of development. Uses of water were limited to domestic consumption, powering grist mills, agriculture, fishing, and navigation. The early cases concerned with the use of water recognized that land adjacent to water carried a right to use the water. The question was — what legal standard would allow the greatest beneficial use of the rivers and lakes?

The onset of industrialization created a demand for power generation and waste disposal. To meet this need, industries were located adjacent to rivers. Their activities interfered with the flow, however, which soon created problems. Increased conflicts resulted in court decisions establishing the principle that each riparian landowner has a right to use a river as it passes his property. However, there is no right to injure another riparian landowner. Thus only minor changes to a river were permissible. This principle is called the 'natural flow theory.'

As industralization increased so did the need to consume water. Steam powered generators allowed mills to move from stream banks and consumptive needs increased. New lands were developed requiring irrigation. The doctrine that left a river substantially unchanged became inappropriate. The result was a split in the common law riparian rights. A number of states created the 'reasonable use theory,' while in others the older, 'natural flow theory' prevailed (Hanks 1968).

Under the natural flow theory, a riparian owner has an obligation to leave unimpaired the quantity and quality of the water flowing by his land. The water can be used by the riparian owner as long as he does not materially change it. All riparian land owners have an equal right to the river, and the exercise of this right may not infringe upon the rights of others on the stream. Although this may have been a good doctrine when the same amount of water was needed to be passed from mill to mill for power, it prevents many beneficial uses and is not always strictly enforced (*Mason v. Hoyle* 1888).

Under the reasonable use theory, each riparian landowner has a right to the reasonable use of the water and can prevent unreasonable uses by others. If the use has economic and social value and does not materially harm others, it may be allowed. The problem with a standard based on reasonableness is the inability to predict the uses that will be allowed in a particular situation. One hundred years ago it was acceptable to dump untreated pollutants into rivers. Today that is not necessarily reasonable because 'reasonableness' changes as society's values change. In addition, a use of water on one river may not be acceptable on another because of the characteristics of the river or because of the type of harm that occurs to other riparian owners. On the other hand, a landowner could begin a new use of water which harms his neighbor if the new use provides great benefit against only moderate harm. For example, in an arid area or in time of drought, it may be reasonable to dry up a river.

Although these two riparian rights theories have been discussed as if they are well separated, many court cases in fact mix them. The same court may use both, choosing the theory to meet the facts of the case. Water law in the East, South, and Midwest is not a matter of common law alone; legislation has been passed with many states adopting a permit system. Also, because municipalities did not fit into the riparian system very well, they were granted special power to obtain water.

Which land has riparian rights? One rule states that water may not be taken outside the watershed in the riparian rights system (Farnham 1972). This has created considerable concern recently in eastern areas with water shortages (Abrams 1983). If water from a stream is taken outside the watershed, it is lost to the downstream riparian owners. Such a diversion may be rational, if common property rights exist only in riparian owners. If common property rights in a river belong to 'all' the people, it does not.

Another rule states that the water must be used on adjacent land. There are four theories that have been used to explain which land is adjacent. The 'government survey' rule limits riparian rights tc the original government grant adjacent to the river *(Crawford v. Hathway* 1903). The only reason for this is to remain consistent with the federal practice of limiting the amount of land granted an individual. Otherwise the doctrine seems arbitrary (Farnharm 1972).

In the 'smallest tract' rule, the smallest parcel of land adjacent to the river in the history of the title has rights. If a landowner sells land away from the river, that land loses its riparian rights. The rights remain only with the parcel adjacent to the stream. This means that riparian rights apply to a continually decreasing amount of land and can never be increased *(Boehmer v. Big Rock Irr. Dist.* 1897).

The 'no limit' rule is the opposite of the smallest tract rule, putting no limit on the size of a tract of land. If a riparian land owner buys adjacent land the new common unit has riparian rights. This allows the amount of land with riparian rights to be expanded. Increasing the amount of land with water rights might interfere with other established rights since more water could be consumed than before. However, this theory is well accepted in the United States *(Jones v. Conn.* 1901).

The 'reasonable limit' rule suggested by Farnham (1972) would allow the expansion of riparian land as in the no limit rule, but would contain it to land within a reasonable distance of the river. This reasonable distance limitation would protect other riparian owners, with the extent of the protection depending upon the interpretation of 'reasonable.'

Today, both the appropriation and riparian rights systems have been modified by permits. However, they still remain distinct with the following major differences (Beuscher 1961:449; modified):

1. *The right is attached to adjacent land in the riparian system and in the appropriation system it is given to someone who diverts water and applies it to a beneficial use.*
2. *Non-use will destroy the right in the appropriation system, but a riparian owner does not lose it and can establish new uses.*
3. *Riparians use the water on contiguous land within the watershed, but appropriators may use the water anywhere.*
4. *Riparians share in the reasonable use of water with no fixed quantity assured them. An appropriator has a right to a specific quantity subject to the priority date.*
5. *In time of shortage all suffer equally in the riparian system, but in an appropriation state priorities control water allocation.*

These differences are blurring with the addition of a priority concept to the approval of permits in some eastern states and the distinctive way cities are treated under both systems.

Federal Rights

Although state water law has major responsibility for the allocation of water rights, federal law must also be considered, as the power of the federal government to control the use of water under the constitution is extensive. For example, constitutionally granted federal rights are superior to state rights.

Constitutional Power

The parts of the constitution that can be used to control water include: the treaty power, the war power, admiralty jurisdiction, the general welfare clause, the property clause and the commerce clause (Leighty 1970). Federal power under these provisions is often stated in terms of power over navigable waters with different definitions for navigability.

The treaty power *(Oklahoma v. Texas* 1922) and the war power are seldom used for controlling water use, but the potential is there. In the past, admiralty jurisdiction cases have involved personal injury and other tort liabilities, but this jurisdiction could be used to extend control over recreational boating (White 1958a; Note 1968, 1978). The general welfare clause has been used in association with reclamation projects allowing federal programs to prevail over conflicting state ones *(Ivanhoe Irrigation Dist. v. McCracken* 1958). The property clause creates the power to control federal lands.

The most important of these clauses is the commerce clause. In 1824 Chief Justice John Marshall of the United States Supreme Court held that commerce included transportation and that commercial navigation was part of transportation *(Gibbons v. Ogden)*. The traditional definition for navigability that has developed under the commerce clause is not the same as the one used to determine bed ownership discussed in Chapter 3 and may no longer be valid after the *Sporhase* case to be discussed below. In ownership cases the water bodies must be "susceptible of being used in their ordinary condition, as highways for commerce . . ." *(The Daniel Ball* 1870). Under the commerce clause a water body is navigable if it can be made so by reasonable improvements. Improvements do not actually have to be made or even authorized; it is enough that they are possible. The determination of 'reasonable improvements' is not fixed at some past date, but may be made at some future time so that places not now navigable may become so in the future *(United States v. Appalachian Elec. Power Co.* 1940).

Also, the water body must form a 'highway for interstate commerce.' It is not enough that it is navigable only within the boundaires of one state, although that would be sufficient for bed ownership under the federal test. Under the commerce clause the water body does not have to be used for commerce, it need only have an 'effect' on 'interstate' commerce. This means that non-navigable tributaries of navigable rivers can be regulated because they "affect" navigable streams *(Oklahoma ex. rel. Phillips v. Guy F. Atkinson Co.* 1941; *United States v. Rio Grande Dam & Irr. Co.* 1899).

It is possible for a landlocked water body to be navigable under the federal test for bed ownership purposes but not under the commerce clause. In ownership cases 'navigation' must have actually occurred at some time (Davies 1978a), but if no state line had been crossed it might not be 'interstate' commerce. This happened with the Great Salt Lake *(Utah v. United States* 1971; *Hardy Salt Co. v. Southern Pacific Transp. Co.* 1974).

The definition for admiralty jurisdiction is interpreted differently from the one used for bed ownership. Admiralty jurisdiction is not related to any date (*United States v. Appalachian Elec. Power Co.* 1940), while bed ownership tests navigability at statehood. Canals and other artificial water bodies can be navigable for admiralty jurisdiction (*Ex parte Boyer* 1884), but for bed ownership they must be in their "natural and ordinary condition" (*United States v. Holt State Bank* 1926).

Although navigability under the commerce clause and admiralty jurisdiction have been defined similarly by the Supreme Court, in recent legislation Congress has employed an expanded definition of commerce, making its power under the commerce clause seemingly without limit. The Clean Water Act is one of the best examples of the expanded use of the commerce clause. In the act, navigable waters are defined as "the waters of the United States including the territorial seas" (33 U.S.C. § 1362, 1978). Although this may seem vague, it has been upheld by a federal district court (*United States v. Oxford Royal Mushroom Products Inc.* 1980) and is given the broadest meaning possible in the seventh circuit (*United States v. Byrd* 1979). There is still no United States Supreme Court opinion on this. The present definition of waters of the United States derived from this act includes:

> *(a) All waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;*
> *(b) All interstate waters, including interstate "wetlands";*
> *(c) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, "wetlands," sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any such waters:*
> *(1) Which are or could be used by interstate or foreign travelers for recreational or other purposes;*
> *(2) From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or*
> *(3) Which are used or could be used for industrial purposes by industries in interstate commerce.*
> *(d) All impoundments of waters otherwise defined as waters of the United States under this definition;*
> *(e) Tributaries of waters identified in paragraphs (a)-(d) of this definition;*
> *(f) The territorial sea; and*
> *(g) "Wetlands" adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a) through (f) of this definition.*
> *(40 C.F.R. § 122.4, 1983)*

Legislative history (1972 U.S. Code Cong. and Admin. News 3821) suggests the intent of Congress was to affirm the idea that all water in the United States is navigable. Representative Dingle, a supporter of the measure, explained the phrase by saying 'water of the United States' was used in a geographic sense rather than in the sense of the technical legal definitions often associated with the term 'navigable water' (118 Cong. Rec. 33756, 1976). The evolution of the navigation concept from ocean going navigation represented by the ebb and flow of tides, to all water geographically within the United States, whether it can be 'navigated' or not, represents a significant change. Navigability for purposes of the commerce clause has become a term related to the public's interest in water, with the ability of a boat to float on it becoming less important.

Not all federal legislation extends the commerce clause concept of navigation as far as the Clean Water Act, however. Since acts of Congress are designed to accomplish specific purposes, they all need not be as expansive. In 1890 Congress passed an act pursuant to the commerce clause which prohibited obstructions to the "navigable capacity" of waters within the United States (26 Stat. 454). The Rivers and Harbors Act of 1899 (33 U.S.C. § 407, 1970) made it unlawful to discharge refuse into navigable waters. Under the Federal Power Act of 1920 (16 U.S.C. § 791a, 1974) the Federal Power Commission was authorized to issue licenses for almost all projects that had material effects on stream flow. Flood control activities may also be regulated (33 U.S.C. § 701, 1970).

Federal power under the commerce clause has been summarized as follows:

> *The power to control navigation and navigable waters includes the power to destroy the navigable capacity of the waters and prevent navigation by the construction of obstructions. It also includes the power to protect the navigable capacity by preventing diversions of the water itself, or of the non-navigable tributaries that affect navigability, or by preventing obstructions by bridges or dams or by constructing flood control structures on the navigable waters or on their non-navigable tributaries or even on the watersheds of the rivers and tributaries. The powers to prevent obstruction in turn lead to powers to license obstructions. The power to obstruct leads to the power to generate electric energy from the dammed water (Trelease 1961:400, footnotes omitted).*

A more recent statement by the Supreme Court includes groundwater as an article of commerce (*Sporhase v. Nebrasksa* 1982). Since legislation passed under the constitutional authority of the commerce clause prevails over conflicting state law, the federal definition of navigable water will have a considerable impact on resource use. This can be demonstrated by the following example.

In 1949 the state of Washington passed an act prohibiting the construction of dams over 25 feet high on some of the tributaries of the Columbia River. The statute was enacted to protect anadromous fish. The city of Tacoma wanted to build dams 510 and 240 feet high on the Cowlitz River, which was one of the regulated tributaries. It applied for a license from the Federal Power Commission who granted it after a 'finding of need.' The state objected because it wanted to leave the river in its natural condition. The authority of the Federal Power Commission to issue the license was challenged, but the state lost because federal power is supreme when dealing with electric power (*City of Tacoma v. Taxpayers of Tacoma* 1953).

This did not end the dispute, because there was a state fish hatchery on the river. A Washington court ruled in *City of Tacoma v. Taxpayers of Tacoma* (1957) that the city of Tacoma did not have the power to condemn the hatchery in order to construct the dams. The hatchery was on the river and would be destroyed by the completion of the project. The United States Supreme Court (*City of Tacoma v. Taxpayers of Tacoma* 1958) reversed the decision, ruling that state law could not prevent the one who received the license from building the dam. In response the people of Washington passed an initiative in 1960 that would have prevented construction. This was overturned by the Washington Supreme Court again, because of federal supremacy (*City of Tacoma v. Taxpayers of Tacoma* 1962).

This demonstrates that federal authority under the commerce clause is 'supreme' in controlling navigable waters. It also shows that the goals of one segment of society may be overridden by national policy. The city, in following federal policy under the Federal Power Act, was able to suppress the wishes of the people of the state after the federal license was issued.

Types of Federal Rights

There are several types of water rights exercised by the federal government (Trelease 1978). Inherent rights result from the exercise of constitutional power, as discussed above. Also, the federal government has rights established under state law. If the federal government acquires a piece of land, rights that were attached to the land pursuant to state law persist in becoming what is known as 'federal acquired rights.' The government may also apply for an appropriation permit under state law, even though it may not be needed (*County of Trinity v. Andrus* 1977). Furthermore, there are reserved water rights outside the state allocation system on federal lands.

The federal government retained ownership over public land until it was granted to individuals under authority of the property clause. At times land was withdrawn from agricultural or mineral entry and set aside for some special purpose. National parks, national forests, and Indian reservations fit this category. A body of special federal water rights developed for this type of land. In 1908 the United States Supreme Court recognized that a group of Montana Indians had a water right with a priority over those granted under state law (*Winters v. United States* 1908). This became known as the 'Winters,' or 'reserved rights,' doctrine. When the government withdraws part of its land from the public domain, it simultaneously reserves a water right which is large enough to accomplish the purposes of the reservation.

Only unappropriated water can be reserved, and rights already established under state law have priority. But the federal right is not recorded, not fixed to a specific amount, and need not be a 'beneficial purpose' for state law. A priority date attaches to the water right at the time the reservation is made. Water rights for Indian lands may thus have an early priority, since many reservations were established before non-Indian settlement. The right is not subject to state law on abandonment and cannot be lost through non-use. If the purpose of the reservation expands, it may be possible that the accompanying reserved water right would expand also. In this case the added portion of the right might have a later priority, dating from the time of expansion.

A major Supreme Court decision (*Arizona v. California* 1963) started a flurry of litigation which has begun to define the limits of this doctrine. In that case an Indian reservation was held to own the rights to enough water to serve all of their irrigable land. *United States v. Cappaert* (1976) centered on water in a pool that was the home of the devil's hole pupfish. Pumping of ground water was draining the pool. The area was a national monument which had been set aside, in part, for the preservation of the pupfish. To 'accomplish this purpose' the federal government had reserved a water right — enough ground water had been reserved to keep the pool level at a sufficient height to allow pupfish breeding. Any use, however lawful under state law, that interfered with the federal right was declared subservient to it.

For a period of time in the 1970s it looked as if the federal reserved water right might completely swallow state water law. One attempt was made to exercise a water right on national forest land for minimum stream flows, and scenic and recreational uses. The Creative Act of 1891 (26 Stat. 1095 & 1103) and Organic Administration Act of 1897 (16 U.S.C. § 471, 1974) were being relied upon to show that Congress intended the national forests for such purposes when they were set aside. However, the Supreme Court decided (*United States v. New Mexico* 1978) that the intent of these acts was merely to grow trees and protect the watershed. Since there was no early intent for other purposes, the amount of water claimed under this doctrine was deemed much less than was asserted.

The major reserved rights remaining are those attached to Indian lands. Reservations were established in order to 'civilize' the Indians (*Winters v. U.S.* 1908). What this policy means and how it determines the extent of the water right that goes with the reservation has been subject to considerable litigation. It would seem that if the purpose of the reservation is 'civilization,' the water right should expand and change as the needs of Indian communities change. In 1963 *Arizona v. California* held that Indian reservations had water rights to all 'practicably' irrigable acreage.

When *Arizona v. California* was decided the boundaries of some of the Indian reservations involved in the dispute were not clear. When title to the disputed acreage was finally resolved by a state court, the Supreme Court held (*Arizona v. California* 1983) that water rights existed on the irrigable acreage of these lands also. The Court said, however, that as to the original undisputed acreage, the determination of water rights in 1963 was final and would not be relitigated. This limits the open-ended expandability of Indian water rights. The message is the same in *Nevada v. United States* (1983), where the right to additional water for the Pyramid Lake fishery was denied because the rights had been adjudicated in 1944. Since state courts have the power to resolve Indian rights, and since this determination will be binding, the future needs of 'civilization' may not be considered (*Arizona v. San Carlos Apache Tribe of Arizona* 1983).

The Limit on Federal Rights

The movement of goods across state boundaries within the United States is generally unimpaired. This was not always true. When the Revolutionary War ended, commercial warfare between the states emerged. Economic barriers disrupted trade, and the need for centralized control over commerce was realized. The decision was made that the country must operate as a single economc unit rather than each state having separate control. It was recognized that if each state could regulate commerce entering or leaving its borders, thirteen different sets of laws could create economic chaos (*Hood & Sons v. Dumond* 1949).

The mechanism created to settle this imbroglio was the commerce clause of the Constitution, which grants Congress legislative power over commerce. The clause has been interpreted to be a prohibition on state laws that discriminate against or burden interstate commerce (Tarlock 1983a). The two parts of the commerce clause erase the impact of internal boundaries on trade and create a common national economic policy.

How does federal power over commerce control the distribution of water? Originally the federal government was not involved in controlling water except for navigation purposes, and the states were allowed to develop their own allocation systems. Recently, there has been an increasing federal interest. The limitations on federal power was discussed by the United States Supreme Court in 1982. Although the case was related to groundwater, it also affects surface water.

In 1982 Nebraska had a statute that required a permit be issued before groundwater could be exported. The permit was to be issued if the request "is reasonable, is not contrary to the conservation and use of ground water, and is not otherwise detrimental to public welfare . . ." (Neb. Rev. Stat. § 46-613.01, 1978). However, the permit would not be issued unless the state in which the water was to be used granted reciprocal rights. This would have prevented the movement of water between Colorado and Nebraska.

Joy Sporhase and Delmar Moss jointly owned contiguous tracts of farm land in Nebraska and Colorado. Their well was located in Nebraska and their land in Colorado was irrigated from it. Since they had no Nebraska permit to export water, the state of Nebraska tried to enjoin their out-of-state activities. In the court action that followed, the Nebraska Supreme Court ruled that water was not freely transferable within the state and was therefore not an item of commerce (*State v. Sporhase* 1981). For this reason Nebraska had the authority to deny the exportation of water.

On appeal, the United States Supreme Court (*Sporhase v. Nebraska* 1982) sought to decide three issues: (1) Is water an article of commerce? (2) If so, does the Nebraska statute impose an impermissible burden on commerce? (3) Has Congress granted the states an otherwise impermissible right to regulate?

In addressing whether water was an article of commerce, the court considered two contradictory precedents. In 1908 the Supreme Court upheld a New Jersey statute that prevented water from being exported (*Hudson Co. Water Co. v. McCarter*). Many issues were involved in that case, but only three sentences addressed the commerce clause. The other precedent was a three-judge federal district court (*City of Altus v. Carr* 1966) which found a Texas export ban of water an impermissible burden on interstate commerce. The United States Supreme Court had affirmed this without making a written decision. Resolving these opinions the Supreme Court in *Sporhase* said:

> *But appellee's claim that Nebraska groundwater is not an article of commerce goes too far; it would not only exempt Nebraska ground water regulation from burden-on-commerce analysis, it also would curtail the affirmative power of Congress to implement its own policies concerning such regulation. If Congress chooses to legislate in this area under its commerce power, its regulation need not be more limited in Nebraska than in Texas and states with similar property laws. Ground water overdraft is a national problem and Congress has the power to deal with it on that scale (346; citations omitted).*

This means water is an article of commerce and Congress has the power to supersede state water law if it chooses. Whether that power is ever asserted at the federal level is a political question.

Holding that water is an item of commerce, the Court next had to determine whether the Nebraska statute was an impermissible burden on commerce. State statutes are permitted to affect commerce: (1) if a legitimate local purpose is found and the burden on commerce is not excessive when compared to the local benefits; and (2) if there are no alternatives with a lesser impact (*Pike v. Bruce Church, Inc.* 1970).

One local purpose stated by Nebraska was to preserve and conserve diminishing groundwater sources. The court found this to be a legitimate purpose, especially since people within the state were being restricted in the way water was used. However, the court could not find any evidence that the reciprocity provision was tailored to the goal of conservation and preservation. In an interesting bit of dictum, the court left the door open for possible future bans. It said: "[a] demonstrably arid state conceivably might be able to marshall evidence to establish a close means-end relationship between even a total ban on the exportation of water and a purpose to conserve and preserve water" (3465). Since the statute did not satisfy the first condition, the court did not need to examine whether there were alternatives with a lesser impact.

The third issue before the Court was important because Congress can grant the states the power to enact legislation that would otherwise be impermissible under the constitution. Nebraska argued that the thirty-seven federal statutes that defer to state water law did this. Most of these statutes state that nothing in them is intended to interfere with state water laws and that federal agencies must act in conformity with those laws. The Court did not agree with this argument, deciding that the grant of power to a state must be expressly stated in a statute in order to affect interstate commerce.

In rejecting Nebraska's statute, the Court set standards under which other state statutes could be judged. In January 1983 those standards were interpreted by a federal district judge in New Mexico.

Currently El Paso, Texas, obtains its water supply from within the state. Since these supplies will be insufficient in the future, El Paso sought to obtain groundwater from neighboring New Mexico. The city applied for 326 permits to appropriate 296,000 acre-feet of water, but the permits were denied — New Mexico statutes prohibited the exportation of groundwater (except for one inconsequential provision; N.M. Stat. Ann. § 72-12-19, 1978). El Paso sought an injunction to prohibit the ban (*El Paso v. Reynolds* 1983). While most of the resultant court decision addressed unrelated jurisdictional issues, the commerce clause was also discussed.

An absolute ban on exporting water is a basically discriminatory statute and is subject to the strictest scrutiny under the commerce clause. This is a stricter standard than was applied in the *Sporhase* case because the New Mexico statute prohibits all exports. Applying this standard to the New Mexico statute the district court ruled that New Mexico "must demonstrate that the embargo serves a legitimate local purpose, that it is narrowly tailored to that purpose, and that there are no adequate non-discriminatory alternatives" (388).

New Mexico maintained that the purpose of the export ban was to conserve and preserve the state's water. The court thought this was a legitimate purpose under the three pronged test in the preceding paragraph, but it was not enough to support a discriminatory total ban. Interpreting *Sporhase* the court said:

> *[A] state may discriminate in favor of its citizens only to the extent that water is essential to human survival. Outside of fulfilling human survival needs water is an economic resource. For purposes of constitutional analysis under the Commerce Clause, it is to be treated the same as any other natural resources (389).*

The court determined that New Mexico had no shortage of water for health or safety reasons and would not in the near future. The need for water for irrigated agriculture and energy production was said to be a matter of economics, not health and safety.

The court characterized New Mexico policy as being "tantamount to economic protectionism." Keeping water for economic development in New Mexico while denying it for economic development outside the state is discriminatory and goes against the principle that the county has a single nationwide economic unit — not 50 states. This does not mean that New Mexico cannot conserve or preserve water — only that interstate and intrastate uses must be treated equally, unless there is a threat to health and safety.

The court also rejected the New Mexico statute under the second test, because it was not "narrowly tailored" to achieve the local purpose. The statute did not restrict any in-state uses of water. Indeed, permits were not denied if there was unappropriated water. When this is added to the fact there were alternate ways to accomplish the state's purposes, the court concluded the ban was unconstitutional.

In interpreting the commerce clause and its application to water exportation, a two level analysis is needed (Tarlock 1983a). If a statute basically discriminates against interstate commerce or citizens of another state, then it will be strictly scrutinized. An example of this is the absolute prohibition. In order for this type of statute to be constitutional it must: (1) serve a local purpose related to public health and safety; (2) be narrowly tailored to that purpose; and (3) have no nondiscriminatory alternatives available. This is a difficult standard, and it is doubtful that many anti-export statutes could meet it.

If the statute is not basically discriminatory then another test is used. In this test there needs to be: (1) a legitimate local purpose; (2) benefits outweighing the burden imposed on commerce; and (3) no alternatives with a lesser impact on commerce. This creates a balancing test in which burdens and benefits are weighed. Clearly this test is easier to meet than the one used for basically discriminatory statutes.

There are still possibilities for state control of water exportation. The first step is to treat all appropriators the same whether they are from inside or outside the state. This eliminates basically discriminatory statutes. The statute must have a legitimate local purpose, like water conservation. In areas where demand exceeds supply there will be more room for restrictions than where there is a surplus of water. Draw-down restrictions, well spacing, pumping rates, and anti-mining statutes could be justified where water is limited. A comprehensive conservation plan which uses a variety of devices is most likely to succeed, since alternatives with lesser impacts on commerce will not be excluded.

There is another way states may be able to control their water. Congress can authorize a state to pass a statute which would otherwise impermissibly burden interstate commerce. At present there are several bills in Congress which may have some impact. These bills are aimed at granting coal slurry pipeline companies the power of eminent domain so they can condemn a right of way. One bill would allow otherwise impermissible state restraints on interstate commerce. Others would allow for a free market environment or consider only the exportation of water for coal.

Legislation on this issue could remove it from the judicial arena. Otherwise, courts will continue to make the decisions. It may be that politics, not law, will provide the proper forum for this issue.

Decentralizing water resource planning and management

William C. Wright, Ronna Cohen, and Jeffrey H. Heath

The historic tug of war between federal, state, and local agencies for water resource control has contributed greatly to problems facing the water industry. States are in the best position to coordinate varied interests and to refocus emphasis on local input. Integrating water management techniques with ongoing state water planning offers public assurance of continuing reliable and cost-effective water service.

The water industry in the eastern states currently suffers from acute neglect. During the 1970s, rampant inflation and decreasing revenues "... bequeathed dilemmas rather than the resources to keep pace with infrastructure decline. . . ."[1] The situation was compounded by an emphasis on wastewater treatment that left few or no funds for energy for water projects.

The comprehensive state water planning process is a broad-based information gathering approach to addressing the problems of the water industry. Designed to advance efficient water use, this scheme seeks to eliminate duplicate efforts in neighboring locales by promoting political cooperation, regionalization, and consolidation. Revitalizing the industry's decaying infrastructure depends on these initiatives; what remains is to apply fiscal and managerial ingenuity to the entire process.

States, by virtue of historic precedent, are responsible for their own water resource activities. Thus their main role is to provide a water management and allocation strategy and a multipurpose state water plan so that local utilities can coordinate decision-making. An integrated framework is requisite to planning and regulating the use of water resources. Supportive arguments suggest that regulation and planning are symbiotic. Each provides a touch of reality and practicality to the other. Goals and policies represent workable elements applicable in the field, and regulation prevents case-by-case decision making.[2]

The purpose of this paper is threefold: (1) to analyze historic water resource development to establish a

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rationale for the existing relation among, and efforts of, federal, state, and local entities in water resource activities; (2) to survey 21 eastern states (Figure 1) and to discuss their efforts and problems associated with water resource affairs; and (3) to outline a methodology for states to consider in developing water allocation strategies and a resource planning program.

Background on resource allocation and comprehensive planning methods

Riparian and appropriation water allocation doctrines. All eastern states adhere to the principles of the riparian doctrine, in whole or in part. The riparian doctrine guarantees the rights of users located along natural watercourses to recover water that is undiminished in quality and quantity from upstream users. Protection is currently offered only when an upstream diversion interferes with a downstream use of water. Water rights in the West grew from a different set of rules. Water was appropriated for perpetuity to those who first staked claim to, and made good use of, any given amount of water.

Both doctrines adequately addressed water needs for early mining operations, power for millworks, and individual domestic use. The intrinsic inflexibilities of both doctrines surface when confronted with the present demand from municipalities, industries, and agriculture. Thus, attempts at increasing demand from or altering uses of intrastate and interstate resources resulted in aggressive challenges to the fairness of common law water allocation methods.[3]

The courts responded by apportioning water among competing users with less than satisfactory results.* Technical complexities in allocation issues fostered unpredictable and costly legal decisions.[4]† Other criticisms of the riparian and appropriation doctrines are presented in Table 1. Consequently, the development of alternative regulatory methods became imperative.

Alternatives to common law allocation methods. State water agencies are increasingly adopting some form of a permit system for intrastate water.‡ Seven of the states shown in Figure 1 use permit systems that combine the positive elements of the riparian and appropriation doctrines[5] to maximize reasonable, beneficial use.[6]

States and, at times, the federal government settle interstate water allocation issues by negotiation. One method is by interstate compacts that are usually for a single purpose and are congressionally approved agreements negotiated by the states involved.§ Alternatively, federal interstate compact commissions offer a unique structure for comprehensive planning, water allocation, and water facility construction and operation.[7] State and federal representatives negotiate these compacts in a cumbersome, tedious process. However, the longevity of interstate compacts and compact commissions supports claims of their effectiveness.

Comprehensive intrastate planning of land and water resources. The Theodore Roosevelt administration (1901-1909) acknowledged the need for uniform national policies.[8] At the time, complex, capital-intensive construction projects for navigation, irrigation, western land settlement, and soil and water conservation were best undertaken by the US Army Corps of Engineers, the Bureau of Reclamation, and the US Soil and Conservation Service. The states feared this emerging federal role and after World War II aggressively sought inclusion in federal agency affairs. Some federally commissioned reports favored federal leadership in preparing comprehensive plans for each river basin in the country.[9] Others opposed such moves as an infringement on states' traditional rights.[10-12] Federalism won over a states-oriented school of thought.

A centralized, national approach initiated by Congress came with the Water Resources Planning Act of 1965.[13] The Water Resources Commission (WRC) was established to coordinate the activities of the newly formed Title II interstate river basin commissions and federal water agencies and to provide funds to states that began a comprehensive intrastate water and land planning program under Title III.

The intent of Title III was to spur the establishment of ongoing state comprehensive planning programs with federal dollars. All 21 eastern states studied participated in Title III funding programs.[14] The high expectations were rarely met.* Only 11 of the 21 eastern states studied took the first step towards an ongoing program—a legislative mandate for comprehensive water and land resource planning. As illustrated in Figure 2, the eastern states have not taken this first step as quickly as their western counterparts. Table 2 and Appendix 1 present a summary of state efforts in comprehensive planning and management.

There are reasons for this lackluster performance by the eastern states. When Title III funds became available in 1967, wastewater was the priority problem, not water. The states found it hard to justify budgeting monies beyond those required to match federal shares. The allotments were insufficient to sustain the planning effort, and water resource divisions suffered. With substantial federal wastewater subsidies flowing into the states, it is not unreasonable to presume that the states expected, and therefore awaited, similar federal subsidies for water resources.

During the past five years, infrastructure decay, hazardous waste pollution, and water shortages have plagued the traditionally water-rich eastern states. The former emphasis on wastewater has been superseded by a concern for water. Many states and local utilities have been ill-prepared financially, administratively, and managerially. Again, the question arises as to the degree the federal government will intervene in intrastate water resource affairs.

New federal initiatives for water resource development. By eliminating federal participation in Title II river basin commissions and Title III assistance to state planning, the Reagan administration sent two divergent messages.

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*In the Delaware River Basin, the states recognize that a 1954 Supreme Court decree concerning water allocation is unworkable during low flow. A proper modification could take years.

†The article cited reports total litigation and court costs of $50 million for *Arizona v California*, 373 US 546 (1963).

‡Maryland and Florida have authorized a consumptive use permit system across the entire state. Kentucky, New Jersey, New York, Delaware, North Carolina, and Georgia regulate those areas subject to potential shortages, often referred to as "protected" or "capacity use" areas.

§The Potomac River Low Flow Agreement is a compact that sets withdrawal levels for each signatory state.

*Some states, notably Pennsylvania and New York, provided sufficient state funds to complete their plans. However, New York has in recent years used Title III funding to support reservoir management, conservation, and stream flow rehabilitation instead of updating plans. Virginia had completed four of nine subbasin plans before work was suspended.

One tells the states to go it on their own.* The other signal, coupled with loosened controls on planning requirements for the US Army Corps of Engineers,[15] gave federal water agencies and the Department of the Interior a virtual free hand in deciding what approach to take in water resource development.[16]

Congress, undaunted by the limited progress in achieving the objectives of the Water Resource Planning Act of 1965,[17] still supports coordination of water resources at the national level. Three bills currently before Congress provide no new answers but further the federal centralization trends. Appendix 2 compares these bills.

In addition to the general trend since the late 1960s towards centralized government, historic precedent supports congressional skepticism of the states' ability to address complex water resource issues. Prior to 1970, the traditional congressional approach to pollution control relied on state and local action to accomplish federal abatement goals and was carried over to the Water Quality Control Act of 1965.[18] The failure of the states to accomplish the formidable goals of the act resulted in the Water Pollution Control Act of 1972[19] with its emphasis on federal standards, enforcement, and construction specifications. Congress still remembers this nonaction by the states. In fact, a bill sponsored by Senators Domenici (R-N.M.) and Moynihan (D-N.Y.) resembles the wastewater construction grant program that was a part of the Water Pollution Control Act of 1972, offering a 75-25 percent federal-state split for authorized projects developed by state and federal agencies (Appendix 2).

Yet state agencies, local public works, and the nation's water engineers are generally opposed to the inefficiencies caused by federal centralization.[20,21] Having experienced the bureaucratic strangling of the wastewater construction grants program, a strong voice from this constituency prefers to divest water resource programs from federal intervention.

The need for change

The preceding analysis indicates that neither federal initiatives nor state actions have adequately dealt with the complexities inherent in water resource activities. The federal government is too removed from local needs to make efficient, timely, and coordinated water resource decisions. On the other hand, states have been reluctant to accept the responsibilities. Who, then, should provide the needed leadership in shaping an efficient approach to water resource development?

Federal centralization was given its chance in the Water Resources Planning Act of 1965 and failed. The individual parts of the act are sound, but dominance came from the top rather than from the level responsible for implementation—local and state entities. It is now time to decentralize. Management theory holds that decisions are best made at levels closest to the marketplace.

Most states are still not in a position to tackle the complexities of water resource problems. Many eastern states must begin by naming an agency to lead state planning and allocation programs. Others must seek legislative support to create one. All must address one or more of the following problems: (1) separation of departments that deal with quantity of water and quality of water;* (2) lack of statutory authority for planning or allocation (Figure 2); and (3) lack of precedent for complementary management of groundwater, surface water, and land resources.

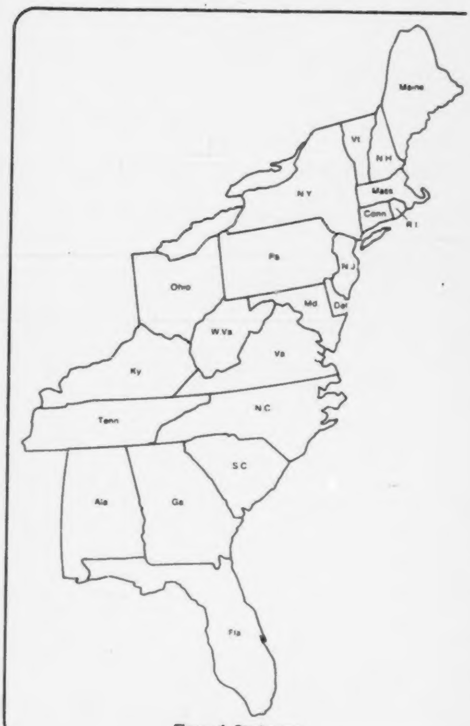

Figure 1. Study area

Even with a sound agency structure there are constraints that favor the status quo of limited state involvement in allocation and planning issues. For allocation, the essence of the riparian doctrine is well entrenched in the decision-making of lawmakers and lobbyists. Many eastern states lack a sound database to establish pertinent criteria.† With planning, the states may experience stonewalling by local water agencies and legislators. Local water agencies, which are fiscally responsible for their own facility planning, may rightfully resist interference. The two levels of planning require coordination. For many, the word "planning" depicts mystical connotations of form without substance. States, like business

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*James G. Watt, Secretary of the Dept. of Interior, as chairman of the Water Resources Council, proposed the repeal of the Water Resources Council principles, standards, and procedures for water and related land resources planning (46 Fed. Reg. 45388 [1981]).

*Eight states have totally separate divisions for water quantity and quality planning. See Table 2.

†States with permit systems, Florida, Maryland, Delaware, Kentucky, New Jersey, New York, and North Carolina, arbitrarily set permit requirements due to inadequate databases.

TABLE 1
Criticism of common law doctrines as a method for water resource allocation[6,22,17]

Riparian Doctrine	Prior Appropriation Doctrine
1. The courts are responsible for settling highly technical water allocation issues 2. Litigation is narrow in scope, time-consuming, and uncertain in its outcome. 3. Conflicts are decided on case-by-case decisions which is inefficient. 4. "Reasonable use" is ill-defined for nondomestic purposes. 5. Confusion over the rights of a riparian owner who is not making use of or intending to make use of any water. 6. Use is restricted to riparian land when more economically beneficial uses may be elsewhere. 7. What once was considered reasonable use may change with time. This may hinder individual growth. 8. Lack of administrative control. Courts are not capable of uniform application of the law.	1. Promotes economic development of land at expense of conserving limited water resources. 2. Uncertainty over rights occur in periods of shortages. Senior owners may receive all water at expense of others. 3. Water waste. Right is lost only when use is abandoned. Therefore to keep the water right, users may draw on the amount whether needed or not.

TABLE 2
State efforts at intrastate water resource planning and management[14]

State	Expressed Statutory Mandate					
	Omnibus Planning and Management	Integrated Water Quality and Quantity Planning	Water Quantity Planning and Management	Water Quantity Planning	Water Quality Planning	Status of Comprehensive Plans
Alabama						None
Connecticut		X			X	None
Delaware	X				X	Begun
Florida	X				X	Near completion
Georgia						None
Maine						None
Maryland			X		X	Begun
Massachusetts						None
New Hampshire						None
New Jersey						None
New York		X			X	Regional plans complete
North Carolina						None
Ohio						None
Pennsylvania		X			X	Near completion
Rhode Island						None
South Carolina				X	X	None
Tennessee				X	X	None
Vermont		X			X	None
Virginia		X			X	Planning suspended
West Virginia		X			X	None
Kentucky						None

corporations, have often resisted planning simply from a misunderstanding of its components and benefits.

All the constraints that accompany the desire to plan and manage water resources can be nullified by bipartisan legislative leadership, clear and precise objectives, and proper procedure. A trend toward nonaction will have serious consequences. Conflicts between competing users and neighboring political entities will continue if there is no efficient means of resolution. Economic stability will be threatened by frequent interruption of an essential service to industries, agriculture, and municipalities. The likelihood of increased federal intervention will further reinforce states' passiveness. The short-term situation (i.e., in political terms) will serve as the major focus at the expense of long-term economies.

The allocation approach

The basic premise of any allocation system is to answer the question: What is the best use? The concern arises in the process of balancing the conflicting definitions of "best," i.e., economic efficiency versus environmental soundness. Recognition that the two traditional doctrines, riparian and appropriation, are not equipped to respond to this dilemma has instigated the search for applicable alternatives. Two theories have been advanced—one based on regulation and the other on a market approach.

Regulation. In the East, the modus operandi for intrastate waters has been regulation based either on areas of critically short supply or on the entire state. The most common mode is regulation in protected areas. Regulation is often instituted with good intentions but is without accurate techniques to measure accomplishments.* For a regulatory approach to be useful, the available amounts of water and the anticipated demand must first be determined. Based on such information, objectives and boundaries of a regulatory system can be set.

Such a system attempts to resolve the question of defining the "best use" in a manner not addressed by the more traditional approaches. However, a permit by definition sets parameters of duration and amount. This, in

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*Alabama currently requires permits for those users exceeding 100 000 gal per day. There is no basis for this amount and no means to identify if this level is sufficient to protect against groundwater mining.

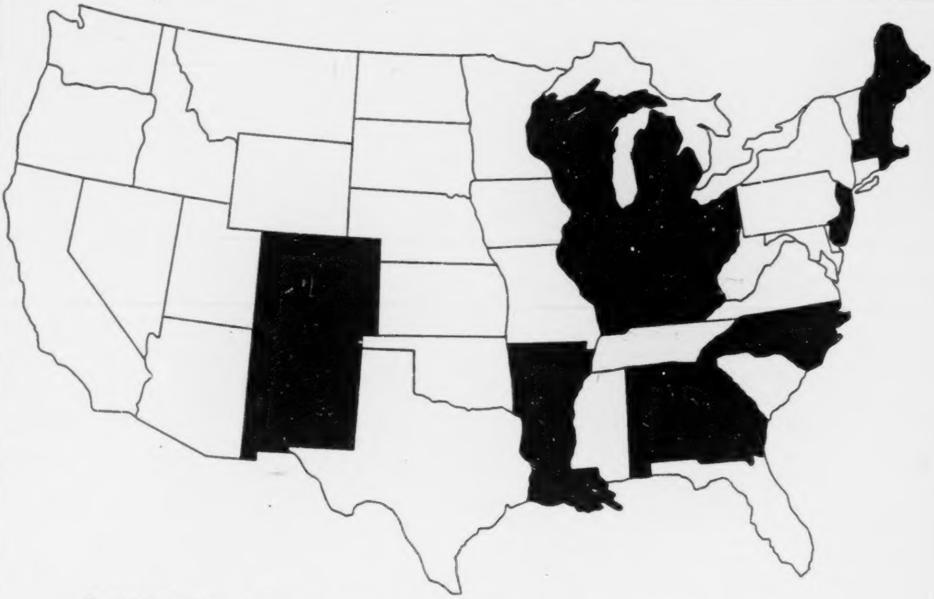

Figure 2. States without legislation to initiate the state comprehensive water and land resource planning process

itself. creates an unresponsiveness to situational changes that may arise during the lifetime of the permit. Even with open-ended clauses built into the contract. all consequences still may not be anticipated. For instance. permits can discriminate against newcomers. Another failing of regulation is a lack of conservation incentives.

Market. Proposals to allocate water via market forces combined with varying degrees of government intervention have been made in response to regulatory insensitivities. Such approaches are analogous to the capital market enterprise of valuing the commodity or "right" in light of supply and demand principles.[22] Thus. a predetermined number of rights are distributed. Thereafter. the quantity available at any one time is a function of willing buyers and new conservation techniques. As eager buyers inflate the price of a right. potential sellers will reduce their consumption to release rights for sale. This will lead to increased economic well-being without necessarily sacrificing environmental ethics. This system may work well in specifically designated critical areas where demand for water exceeds supply and the commodity retains a quantifiable value. This assumes that such areas can be defined and politically isolated for special treatment.

In water-rich areas where supply usually exceeds or matches demand. market forces cannot operate. The right loses its value. and incentives to conserve will diminish or even disappear. Government intervention as a broker or market-maker may be necessary to stabilize the price artificially. which again introduces the frailties of a regulatory scheme.

Using both approaches. The essence of water allocation is data gathering. In critical areas. regulation provides the best means of water management in the absence of data. As data are gathered on water availability versus water use. a market approach may offer the best means of tailoring economic growth to meet societal goals. In areas where water supplies are usually adequate. water management requires a different focus. Registering water users and continuing studies of water resource availability provide the requisite data to determine when a regulatory approach is most appropriate. A solid database reduces the time spent in a purely regulatory mode and hastens the time when a market approach can be introduced to support and supplement the regulatory goals.

The planning process

By definition. planning precedes informed decision making. Too often. planning is viewed as a luxury that is eliminated in times of austerity. Businesses today recognize that growth in hard times depends on following a predetermined. streamlined but flexible course. Strategic planning has become a matter of survival. The

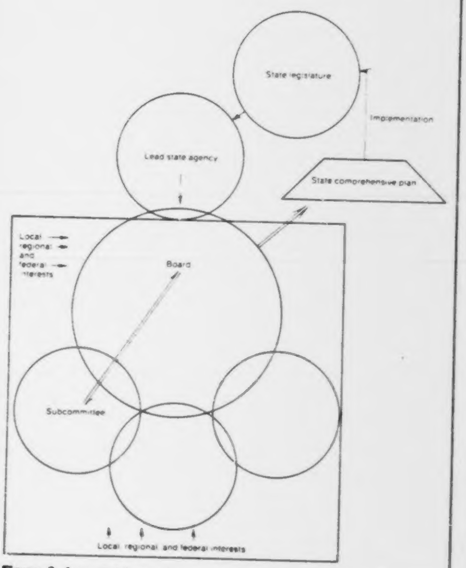

Figure 3. A model for state comprehensive water and land resource planning

water industry and the general public must adopt this clue from the corporate world: water planning functions become most critical when revenues and economic conditions turn downward.

Process structure. The success of comprehensive water and land resource planning depends on: (1) citizens and water utilities recognizing its value; (2) a clear consensus that coordinated efforts aimed at water planning for multiple purposes are the most cost-effective; (3) bipartisan support from state legislatures; (4) developing and maintaining an adequate database; (5) continuous funding to update reports; (6) active public participation throughout the process; and (7) a promise for implementing the plan. Without affirmative responses to these statements, the fears of nonplanners will undoubtedly come true: plans will be mere shells filled with blank pages.

Plan model. The model outlines a planning process with emphasis on the interrelationship of federal, state, local, and private interests. The model is based on planning efforts in Pennsylvania[23] and New York,[24] on accepted business management practices, and on the everyday realities of working within the political system. The model's principles are applicable to all states with only minor modifications to fit specific situations. Figure 3 outlines this discussion schematically.

The state planning process begins with a legislative commitment to ensure that a final plan has a chance to survive and to be implemented. The legislature should mandate a state agency with sufficient powers to initiate and execute the planning procedure. The enactment should not be so site- and method-specific as to inhibit flexible and creative planning. Rudimentary guidelines—goals, strategies, methods of authorizing decisions, and funding allocations—should point to the lowest common denominator of planning, that is, the grassroots needs of a locale.

The lead state agency creates a separate board responsible for the final product. The board's first task is to identify the watershed basins suitable for study, allowing for inclusion of entire political units within the state. Recognizing that political boundaries cross basins, the board has the legislated power to consult and negotiate with contiguous states and is also in a position to integrate federal interests. The board then establishes subcommittees to study each identified basin. The work of the subcommittees is controlled by a system of checks and balances and incremental reviews to reduce wasted efforts and to ensure that plans are compatible with those of neighboring subcommittees. This vertical, flexible communication flow allows any issue to rest at the most appropriate stratum within the hierarchy.

Whereas the board is a middle manager in the process, the subcommittees are the workhorses. They operate at a grassroots level, responding to the basin's constituency—the public, government officials, and local water suppliers—who are best suited to contribute to the planning process. Research to assess needs and to screen alternatives can be accomplished by the subcommittee itself, federal agencies, or private consultants. The plan should be a tool that can be implemented. Once each plan is complete, the board administers a final review and solicits input and comments from those principally involved in the planning program as well as nonparticipants in the process.

Emphasis then shifts from individual basin plans to an overall, comprehensive state plan. Because of the thorough review network between the board, subcommittees, and the public, the individual local plans should need only minor adjustments to fit into the state plan and to conform with the goals of the original legislative mandate. The board at this point can generate both short-term and long-term priorities for implementation. Consistent criteria are imperative to avoid expedient and convenient, but not necessarily appropriate, selections. The criteria and priority list should also reflect the long-term focus of the original mandate.

The process is a closed circle, beginning and ending with the state legislature. Satisfying the political realities is critical to the successful implementation of the plan. To discharge the recommendations, state water legislation must also include a funding and implementation program administered by a single authority, such as the already designated lead state agency.

Plan content. At a minimum, comparisons of scope and content among subbasin or state plans should give uniform and consistent results. No relevant issue can be left unexamined. The content must be broad enough to encompass cross elasticities inherent in water resource issues. At the subbasin plan level, proper coverage will yield workable, self-contained plans. On the state level, a uniform approach increases the likelihood of acceptance

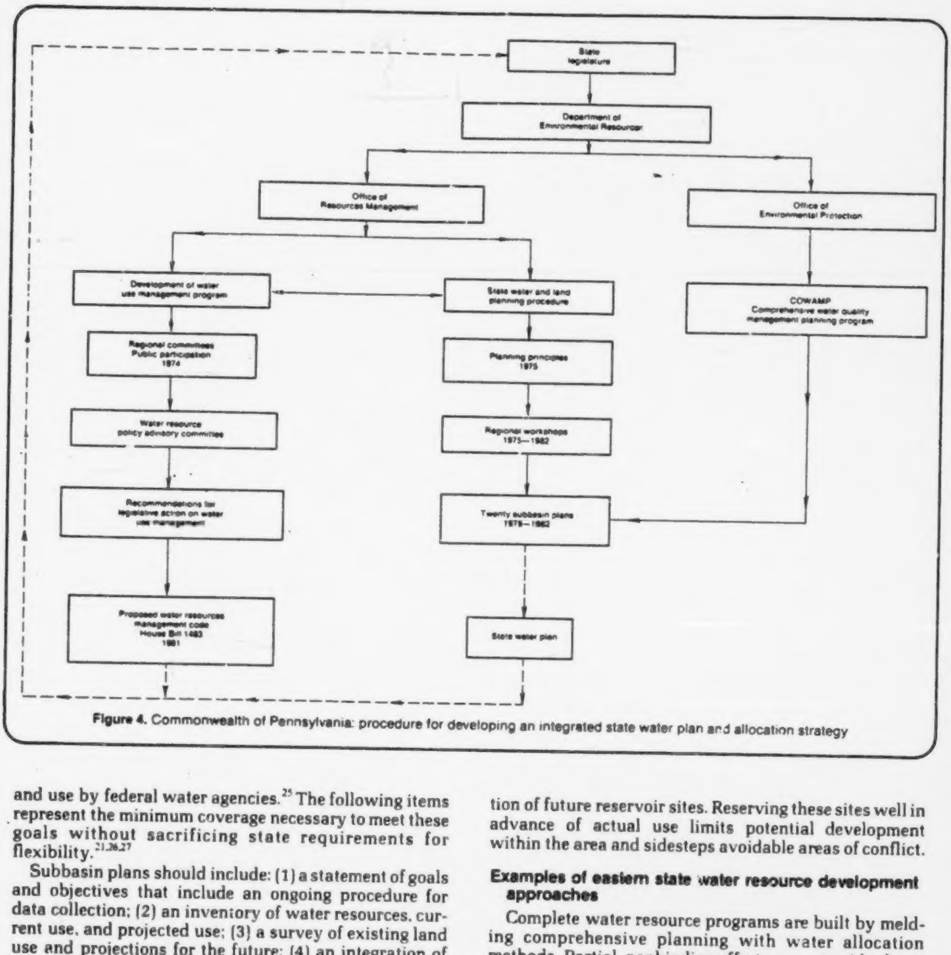
State legislature
Department of Environmental Resources
Office of Resources Management
Office of Environmental Protection
Development of water use management program
State water and land planning procedure
COWAMP
Comprehensive water quality management planning program
Regional committees
Public participation
1974
Planning principles
1975
Water resource policy advisory committee
Regional workshops
1975—1982
Recommendations for legislative action on water use management
Twenty subbasin plans
1979—1982
Proposed water resources management code
House Bill 1483
1981
State water plan

Figure 4. Commonwealth of Pennsylvania: procedure for developing an integrated state water plan and allocation strategy

and use by federal water agencies.[25] The following items represent the minimum coverage necessary to meet these goals without sacrificing state requirements for flexibility.[21,26,27]

Subbasin plans should include: (1) a statement of goals and objectives that include an ongoing procedure for data collection; (2) an inventory of water resources, current use, and projected use; (3) a survey of existing land use and projections for the future; (4) an integration of land use projections in determining water needs; (5) an analysis of the multipurpose nature of water resources including such topics as navigation, recreation, water supply, flood control, wild and scenic rivers, water quality management, and environmental quality; (6) the development of alternatives to meet identified needs and problems; (7) the selection of alternatives based on cost-benefit analyses, social constraints, and the area's ability to pay; and (8) a statement of priorities.

The statewide comprehensive water plan should embody these same elements. However, implementation methods and funding of priorities are emphasized to stimulate identification of obstacles. For example, one important function of a state water plan is the identification of future reservoir sites. Reserving these sites well in advance of actual use limits potential development within the area and sidesteps avoidable areas of conflict.

Examples of eastern state water resource development approaches

Complete water resource programs are built by melding comprehensive planning with water allocation methods. Partial, nonbinding efforts may provide short-term relief but will not necessarily reduce long-term personal and economic hardships caused by shortages and unreliable service. The Pennsylvania and Florida legislatures recognized this by initiating integrated frameworks in the early 1970s. The successes and failures from both states provide good examples for states seeking to adopt or reorganize water resource programs.

Pennsylvania. Pennsylvania began joint allocation and planning efforts with a 1970 legislative mandate to inventory the state's water resources and to optimize use of the commonwealth's water.[28] A schematic of Pennsylvania's approach to this mandate is shown in Figure 4.[23,29,30]

The Pennsylvania Department of Environmental

Resources (DER) initially focused on the Comprehensive Water Quality Management Planning Program (COWAMP). However, work began on water use programs, resulting in the 1975 publication of statewide planning principles. These principles provided a procedural framework for a series of regional workshops from 1975 through 1978. With representation from area planners, local water suppliers, and industry, the workshops focused on problems specific to each subbasin. The results from each workshop were compiled, and in 1978 work began on 20 comprehensive subbasin planning reports. DER is now integrating both COWAMP and these subbasin plans into a statewide water plan.

Concurrently, separate regional advisory committees discussed ways to improve the commonwealth water management and allocation program. Though the committees were adjourned in 1978, their recommendations were used by the Water Resource Policy Advisory Committee (WRPAC) to prepare a report entitled *Recommendations for Water Use Management*. In 1980-1981, the recommendations were submitted to the Pennsylvania legislature, and H.R. 1183 now rests in committee with strong objections from agriculture lobbyists.[11]

Florida. In 1972 a group from the Holland Law Center at the University of Florida developed a model water code to provide procedural regulations within the framework of the riparian doctrine.[12] With slight modifications, the Florida legislature adopted the revised version as the Water Resources Act of 1972.[11] According to the act, the Department of Environmental Regulation (DER) oversees the activities of five independently functioning water management districts.[2,14,15] Together they are responsible for developing a state water use plan and a consumptive use management program.

Flexibilities built into the act allow each management district to grow as required and to focus on individual problem areas. Serious groundwater supply problems and saltwater intrusion led two districts to focus on allocation issues. Management has been a primary concern of all districts. Permit systems are currently imposed in three of the five water management districts. Yet comprehensive planning was not totally ignored. In February 1982, the DER published a report outlining state water use policy guidelines. This report precedes efforts by all districts to inventory water supplies.[16]

Comparison of the Pennsylvania and Florida approaches to integrated planning. Pennsylvania opted to begin the comprehensive water planning process prior to forming allocation strategies. Florida chose the reverse, mostly in response to pressing problems. There is some logic in following Pennsylvania's procedure and pursuing planning first. Effective planning offers legislators a framework upon which decisions that enhance state water resource management can be made.

Both states employ a bottom-to-top approach to water planning. In Pennsylvania, however, subbasin planning was contained within the lead state agency, the Department of Environmental Protection, whereas Florida's lead state agency, the Department of Environmental Regulation, placed major responsibility on its water management districts to complete regional plans. Both approaches respond sufficiently to their state's needs. Florida has taken great pains to coordinate the state water plan with efforts toward completing water quality plans. Unfortunately, COWAMP was completed prior to Pennsylvania's start in water planning.

Two points are worth stressing: both states started with a legislative mandate for action, and both recognized the value of integrating development of regulations with resource plan development.

APPENDIX 1

Water resources planning and management practices for eastern states[14]

State	Methods of Planning or Managing Water Allocations				Legislation	Comments
	Lead State Planning or Coordinating Agency or Office	Interstate Regional Planning Committee (does not include Title II river basin commissions)	Title II Interstate River Basin Commission* (Planning)	Federal Interstate Water Compacts or Commissions (Regulatory)	Applicable Statute Law Mandating Water Resources Planning	
Alabama	Office of State Planning (appointed by Governor)	Southeast Basins Interagency Committee	None	None	Not expressly mandated	Water Improvements Commission responsible for water quality; no state comprehensive water plan; recently involved with development of compact with Fla. and Ga. for Apalachicola Basin (applied for level B study); historically strict riparian state; courts decide conflict; need to develop groundwater data
Connecticut	Department of Environmental Protection	Connecticut Interstate Water Compact Commission (set up by the Governor for assistance on a case-by-case basis)	New England River Basin Commission (NERBC)	None	CSSA Sec. 22a-1 et seq	Continuous water management planning process is mandated (nonbinding); critical need to develop water supply data; lack of conservation effort; no state comprehensive water and land resources management plan has been completed; riparian state; state facing severe water shortages
Delaware	Department of Natural Resources Division of Environmental Control	None	None	Delaware River Basin Commission (DRBC)	7DCA Sec. 6001 et seq	"Omnibus" legislation mandating unified planning and management of water and related land resources; water plan not yet formulated; groundwater supplies depleting; long-term water shortage in Wilmington area foreseen; conservation underdeveloped; riparian state with permit system superimposed as management tool

APPENDIX 1

Water resources planning and management practices for eastern states[14] *(continued)*

	Methods of Planning or Managing Water Allocations				Legislation	
State	Lead State Planning or Coordinating Agency or Office	Interstate Regional Planning Committee (does not include Title II river basin commissions)	Title II Interstate River Basin Commission* (Planning)	Federal Interstate Water Compacts or Commissions (Regulatory)	Applicable Statute Law Mandating Water Resources Planning	Comments
Florida	Department of Environmental Regulation	Southeast Basins Interagency Committee	None	None	14 FSA Sec. 373.013 et seq. (Florida Water Resources Act of 1972)	"Omnibus" legislation authorizing unified administration and planning of water resources: five water districts assume significant roles in administering water programs: groundwater problems (saltwater intrusion—81 percent of population lives in these areas); agricultural withdrawal poses supply problems; taxing authority of water management districts is being challenged; permit system used as management tool; applied for level B study for Apalachicola basin.
Georgia	Department of Natural Resources	Southeast Basins Interagency Committee	None	None	Not expressly mandated	No comprehensive state planning effort (recent application for level B study of Apalachicola basin); groundwater use act establishes mechanism for designating "capacity use" area; groundwater supplies are low, lack of data; shortages expected for industry and irrigation (central Georgia has water shortage); permit system for groundwater or stream withdrawals greater than 100 000 gal/day.
Kentucky	Department of Natural Resources and Environmental Protection; Division of Water Resources	None	None	None	Not expressly mandated	Studies were made, but formal comprehensive planning was not mandated, implementation of water studies are not mandated; eastern Kentucky and Lexington faced with water shortage; lack of conservation implementation; superimpose permit system for regulation purposes; groundwater supplies are low.
Maine	State Planning Office	None	NERBC	None	Not expressly mandated	Water resources studies undertaken within statewide planning effort; need better management of groundwater; conservation efforts need improvement; current planning and management is fragmented; riparian state.
Maryland	Water Resources Administration, Department of Natural Resources	Interstate Commission on the Potomac River Basin (ICPRB)	Ohio River Basin Commission (ORBC)	Susquehanna River Basin Commission (SRBC)	8 MCA Sec. 8-101 et seq.	Legislation mandating planning and management; employs rigorous management practices for water allocation and conservation efforts; permit system; groundwater database needs improvement; 80 percent of surface freshwater originates out of state.
Massachusetts	Water Resources Commission	Northeastern Land and Related Resources Compact (not active in water allocation matters)	NERBC	None	Not expressly mandated	Faced with contamination of water supplies; water shortages in urban areas (western part of the state); lack of conservation effort; uncoordinated planning; riparian state.
New Hampshire	Office of State Planning	Northeastern Land and Related Resources Compact (not active in water allocation matters)	NERBC	None	Not expressly mandated	Studies to be included in overall state planning program; urban water supplies reaching capacity limits; water resources objectives given in state's guide plan (water supply, planning coordination, conservation); no legislation to implement recommendations; riparian state.
New Jersey	Department of Environmental Protection	None	None	None	Not expressly mandated	Comprehensive state planning not mandated; however, a "State Water Supply Master Plan" is being developed as part of an environmental protection plan; severe water supply shortage; conservation efforts directed to emergency plans; governor recently applied for disaster aid because of water shortage; permit system used for regulatory purposes.
New York	Department of Environmental Conservation	None	NERBC ORBC Great Lakes Basin Commission (GLBC)	DRBC SRBC	CLNY, ECL Sec. 15-0101 et seq.	State comprehensive water quantity/quality planning mandated; severe water shortage in New York city area; subbasin plans have been

APPENDIX 1

Water resources planning and management practices for eastern states[14] (continued)

State	Methods of Planning or Managing Water Allocations				Legislation	Comments
	Lead State Planning or Coordinating Agency or Office	Interstate Regional Planning Committee (does not include Title II river basin commissions)	Title II Interstate River Basin Commission* (Planning)	Federal Interstate Water Compacts or Commissions (Regulatory)	Applicable Statute Law Mandating Water Resources Planning	
						completed under level B studies; these have not been combined in an overall state plan (Regional Water Resource Boards developed plans); implementation of plans has not been addressed; inefficient use of existing water resources; permit system for limited regulation.
North Carolina	Department of Natural Resources and Community Development	North Carolina—Virginia Tidewater Area Water Resource Management Committee	ORBC	None	Not expressly mandated	Management directed at largest users in designated "capacity use" areas (permit greater than 100 000 gal/day); no conservation program; need for databases; riparian state with permits for limited regulation; must address interbasin transfer issues.
Ohio	Department of Natural Resources	None	ORBC GLBC	None	Not expressly mandated	Legislation mandates watershed, not statewide planning; does provide for statewide studies; need for conservation has not arisen; riparian state.
Pennsylvania	Department of Environmental Resources	ICPRB	ORBC GLBC	DRBC SRBC	71 PSA Sec. 510-4 et seq.	Nonbinding comprehensive plan has been completed; 13 subbasin reports have been published (20 subbasins studied and reports completed); subbasin plans to be incorporated into statewide plan; newly formed water conservation technical assistance staff; exceeded federal dollars with state dollars during planning development; riparian state moving toward permit system for regulatory purposes.
Rhode Island	Water Resources Board	None	NERBC	None	Not expressly mandated	Legislation does not mandate comprehensive water resources planning but calls for development of water resources; supply shortages; conservation efforts are being developed; riparian state.
South Carolina	Water Resources Commission	Southeast Basin Interagency Committee	None	None	SOCA Sec. 49-3-10 et seq.	Commission mandated to prepare State Water Resources Planning and Policy Framework (nonbinding); water supply planning inadequate; mandates authority to designate "capacity use" areas and requires permits for users who withdraw more than 100 000 gal/day (groundwater); databases are needed; riparian with limited permit system; long-range conservation planning is needed.
Tennessee	Department of Conservation	None	ORBC	None	TCA Sec. 70-2001 et seq.	Legislation mandates long-range water resources policy development; lack of database for surface and groundwater supplies; areas of severe water shortages; quality control problems; riparian state.
Vermont	Agency of Environmental Conservation	None	NERBC	None	10 VSA Sec. 1421 et seq.	Mandated state water plan that will outline means of complementing planning; groundwater provides water supply for approximately half the population; conservation efforts are recognized as essential; lacks comprehensive planning; riparian state.
Virginia	State Water Control Board	North Carolina—Virginia Tidewater Area Water Resource Management Committee; ICPRB	ORBC	None	VCA Sec. 62.1-44.35 et seq.	Mandated continuous, comprehensive planning; completed regional plans for approximately half the state; populous urban areas face major water shortages; two groundwater management areas have been designated; riparian state.
West Virginia	Department of Natural Resources	None	ORBC	None	WVC Sec. 20-1-1 et seq.	Mandated continuous, comprehensive planning (has not authorized implementation procedures); demands approaching present capacity; riparian state.

*As of September 1981, River Basin Commissions are no longer supported (funded) by the federal government under Title II of the Water Resources Planning Act of 1965.

APPENDIX 2

*Analysis of pertinent segments of proposed water resource legislation**

	Domenici-Moynihan Bill S-821	Abdnor Bill S-1095	H.R. 3432
Title	National Water Resources Policy and Development Act of 1981	National Water Resources Research & Planning Act of 1981	Water Resources Policy Act of 1981
Goal	Coordinate assistance to the states for water resources	Amend the Water Resources Planning Act (WRPA) of 1965	Amend the Water Resources Development Act of 1974
	Appropriates national funds to areas that have previously received comparatively minimal funding, such as in the Northeast	Shifts administrative authority from the Water Resource Council (WRC) to a proposed National Board of Water Policy and Office of Water Programs within the Department of the Interior	Shifts administrative authority from the Water Resource Council (WRC) to a proposed National Board on Water Resources Policy
Lead agency	Water Resources Council (or a successor agency)	Office of Water Programs (OWP)	National Board on Water Resources Policy
	The WRC would serve only as a record keeper leaving decision making and priority setting to the states	The Department of the Interior would have greater control over water resource and land use planning and development	Chairman appointed by the President instead of headed by the Secretary of the Interior; expansion of the Water Resources Council (WRC)
Strategy	Establishes a method for identifying needs and authorizing projects developed by state and federal agencies	Reorganizes federal coordination of programs authorized by the WRPA	Reorganizes federal coordination of water resource planning and development
	Allows states to identify their own water needs and projects	Would give decision-making authority to the OWP, which has limited experience in regions of the country not traditionally involved with the Department of the Interior	Does not change the function of the WRC; assumes majority vote will speed the decision-making process
	State allocations are based half on land area and half on population	Allocations are based on population, land area, need for planning programs, and financial needs	Recognized role of the states in the development and implementation of comprehensive water and related land resources management
	This formula would benefit large, populous states such as California and New York	Distribution of funds would not change	Authorizes board to prescribe guidelines to carry out the functions and responsibilities under this act, similar to past federal involvement under WRPA of 1965; implementation strategies are not legislated
	Only 10 regional interstate projects could be under construction at one time	OWP administers both planning and research funds	Board given responsibility for assisting in interagency coordination of research
	Spreads the available funding by limiting one construction project per area rather than allowing one area to receive a greater and thus unfair share	OWP would be able to direct planning and research activities specifically benefiting the Department of the Interior	Enables influential members of the board to direct planning activities to specific regions of the country
Funding	Allocates $2.5 billion among the states for federally designed projects in FY 1983, rising to $4 billion in FY 1988; allocates $150 million annually for studies	Allocates $12 million for state planning in FYs 1982 and 1983, dropping to $10 million in FYs 1984 and 1985, and awarded on competitive basis	Allocates $10 million to state research and planning activities in FYs 1982, 1983, and 1984
	Funding would probably not be provided during the Reagan administration	States are given 2 years to identify water resource problems if funding is to continue for each particular state	No allocation formula is mandated; states to receive not more than 50 percent of the cost to carry out state programs
		Allocates $12 million to the office for dissemination as research grants from 1982-1985	Allocates $2 million to the Secretary of the Army for studies of federal water resources needs in FYs 1982, 1983, and 1984
		No criteria for distribution of funding exists	Singles out the US Army Corps of Engineers to receive funding; no other federal agency is eligible
Authorization	Specific authorization formulas allow for congressional determinations if any party disagrees, adjacent but nonparty states to have a voice, and automatic approval if possible	Similar to the WRPA of 1965 but requires states to assume greater responsibility for making effective use of federal funds	Role of the board is similar to the WRC
	Streamline project review and approval, considers nonparty involvement and interstate considerations, and increases states' autonomy over water resource issues	Implementation of state plans have not been addressed; federal involvement continues; guidance of planning objectives remains vague	Board has no authority to veto or check water policy decisions within the administration; no implementation procedure of completed studies is addressed; thus, the ultimate goals of the Board remain vague

*Significant revisions to these bills may occur during congressional committee review.

Summary

Success in meeting the formidable challenges faced by the eastern states' water industry depends in part on an integrated water allocation strategy and multipurpose state water plan. Traditional approaches in water management and comprehensive planning have been hampered by a lack of commitment, inefficiencies, and a tug of war between federal entities and states for ultimate control. Neither federal initiatives nor state actions have adequately dealt with the complexities inherent in water resource activities. The last 20 years can be characterized as a period of nonaction. The reason stems partly from an unclear relationship among federal, state, and local entities for areas of water resource responsibility. The citizens of many eastern communities are left to suffer from this lack of leadership.

Federal centralization in water resource activities has been proved unworkable by 18 years of unmet goals under the Water Resource Planning Act of 1965. The individual parts of the act are sound, but dominance came from the top rather than from the level responsible for implementation, i.e., local and state entities. Management efficiency dictates that decisions are made best at the levels most able to identify and address specific needs and problems. Both allocation and planning approaches need to be built from the bottom.

States, by virtue of their position in the nation's governmental structure, can become liaisons between the varied interests and complex constraints of the allocation and planning process. They are automatically precluded from operating in a vacuum and thus are best able to mitigate parochialism with federal concerns for national uniformity. Yet most states are not in a position to cope with the Byzantine nature of water resource problems. Leadership must come from state legislatures to form strong, ongoing programs that develop vehicles—water management strategies and multipurpose state water plans—for local utilities to coordinate their decision making. Only this method offers public assurance that water facilities are reliable and that resources match existing needs.

Pennsylvania and Florida are two eastern states that have best applied an ongoing integrated approach to water and land resource planning and management. The successes and failures of both states offer good examples for those who think that an integrated, decentralized approach will provide the most beneficial use of this nation's water resources.

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PROTECTING INSTREAM FLOWS

by Kurt A. Gernerd

The increasing public interest in clean water, coupled with its decreasing availability, has aggravated the conflicts surrounding water resource planning. Policy makers are forced to decide between "consumptive" and "instream" uses of the available water while under a great deal of pressure from various interest groups.

Instream values relate to the possible use of water that is in the stream channel. Usage may include fish and wildlife population maintenance, recreation, navigation, hydropower generation, waste assimilation (sometimes termed water quality), conveyance to downstream points of diversion, and ecosystem maintenance—which includes freshwater requirements to the estuaries and maintenance of riparian vegetation and floodplain wetlands. These uses collectively are "instream values" and the amount of water flowing through a natural stream course sufficient to maintain all of these uses at an acceptable level constitutes "minimum instream flow requirements." At a given location in a given system, only certain uses may be applicable or needed. Instream flow requirements are usually based upon those uses which predominate, either through prior appropriation or local governing attitudes. Situations exist that require tradeoffs to be made within the instream flow section.

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THE ISSUE

Water resource development has often reduced the quantity and subsequently the quality of the natural flows of streams. There is a widespread failure of governments in the United States to protect the many instream uses of water against intensive development for off-stream uses. When consumptive use conflicts with instream use, it may jeopardize recreation, hydropower, groundwater recharge, aesthetics, and fish and wildlife habitat. The conflict between establishment of minimum instream flows for protecting these uses and further water and related land resource development demands is of Federal significance. Some states and local governments have begun to address this conflict by preserving instream flows, but too little is being done at any level of government to bring these values into balance. Meanwhile, the present and future values of many streams and of their related lands and water ecosystems are bing sacrificed.

Fly fishermen in Diamond Fork Creek, near Spanish Fork, Utah. Maintaining an adequate base flow sustains good survival habitat for most aquatic life forms. Water depth is provided for trout movement, spawning, incubation, and winter survival in most run and pool areas of this stream. (Photos courtesy of Utah Water Research Laboratory.)

BACKGROUND

That some western states lack a comprehensive program which recognizes and protects instream values is not too surprising in light of the historic development of western water law. The basic water law of the western states was developed at a time when the prevailing theme was to divert and utilize as much water as was necessary to sustain agriculture, promote and maintain industrial growth, and satisfy community needs (*see "Western Water Law," Vol. 11, No. 3,* Water Spectrum, *Summer 1979*). The prior appropriation doctrine was based upon this concept of diverting the water from the watercourse in order to accomplish a valid appropriation. Water had to be applied to a recognized beneficial use, and, since many states defined beneficial use only in an economic context, the use of water to maintain a fishery or to preserve the stream environment was not considered valid. Nevertheless, the appropriation doctrine remains the principal system by which western states allocate the use of water to private parties.

The water law of England and the eastern states in the nineteenth century was the "riparian" doctrine, which provides that each person owning land adjacent to a stream is entitled to make "reasonable use" of the water along the flow of the stream. Rainfall is a substantial source of water in the eastern states, enough to make irrigation unnecessary in most agricultural pursuits, so little conflict has arisen concerning instream flow requirements there.

Efforts by the western states to protect and preserve instream values as part of their water resource programs have only in the past several years become a matter of concern. The only way states or special interest groups can protect instream flows is through the legal system.

In recent years litigation over environmental issues has increased rapidly and has added to the time and expense involved in resource planning. The United States Supreme Court recently held in *California v. United States* that a state may place reasonable conditions upon water right permits for water in Federal projects and may, within limits, control the distribution of water from such projects.

The First National Water Assessment, completed in 1968, did not address instream flows because of a lack of comparable data, but stated "... in future assessments, a more complete analysis of the adequacy of flow for instream uses will be undertaken."

In 1974, The Second National Water Assessment was undertaken to identify the most severe problems affecting the nation's water and related land resources. This assessment provided the first nationwide examination of instream flow conditions and the implications of accelerated off-stream uses. The plan of study called for a volumetric analysis of the consumptive and nonconsumptive water "requirements" in relation to water supply for each of 106 aggregated subregions or "assessment" subregions. An assessment subregion is a river basin or a group of river basins. As input to the volumetric analysis, a set of numbers was needed to represent instream flow requirements for fish and wildlife. The U.S. Fish and Wildlife Service was assigned to develop these needed numbers.

For much of the nation, there were almost no satisfactory biological data to correlate hydrological data: The data from the large assessment subregions could only indicate conditions in the stream reach near the outflow point(s), and methodologies for quantifying stream flow requirements were not adequate. However, approximations were made to assure that the instream flow values would be considered in the analysis. The Second National Water Assessment provided a major stimulus to select or develop a set of methodologies which could provide approximations of the flow requirements for instream uses.

Grassy Tail Creek, Utah. Minimum instantaneous flows must be able to sustain short-term survival habitat for most aquatic life forms.

Most states now recognize that the protection of instream values is a matter that has been neglected in their overall water resources programs. Considerable public outcry has shown the states that the use of water to sustain fish and wildlife and to provide recreational opportunities for their residents is important. In some states, competition from energy production, irrigation, and public supply demands has prevented the adoption of effective programs to protect instream values. In other states this competition has limited instream protection to modest efforts.

PRESIDENT'S INSTREAM FLOW TASK FORCE

Former President Carter sent his Water Policy Initiatives to Congress on June 6, 1978. The presidential initiative contained five directives pertaining to instream flow problems and their resolution:

1. Federal agencies shall improve, where possible, the operation and management of existing water resource projects to protect instream flow uses.
2. While not interfering with state laws and responsibilities, Federal agencies shall set a strong example in recognizing and protecting legitimate instream flow needs.
3. In planning, Federal agencies shall establish and provide for flow necessary to maintain instream needs below proposed dams or other facilities.
4. For existing water projects that lack provisions for maintaining instream flow, and where commitments and economic feasibility permit, Federal agencies, working in cooperation with the states, shall develop legislative amendments to correct this situation.
5. Agencies will provide increased technical assistance to the states in a cooperative effort to maintain necessary instream flows.

As a result of these directives, several task forces were created to carry out the president's orders. One task force was assigned to investigate instream flows and initiated six major areas to address:

1. Advise the 50 state governments of the president's instream flow directive; assist in making information and technical data available.
2. Request Federal water resource planning agencies to review their procedures to insure that they provide for the maintenance of adequate instream flow below proposed dams and other water resource control facilities.
3. Develop guidelines to determine instream flow for water quality, aesthetic, fish, wildlife, and recreation values.
4. Request agencies to identify, in cooperation with the states: (a) existing projects where instream flow is a problem; (b) corrective measures agencies plan to take, such as operation and management techniques or legislative actions; and (c) when the corrective measures will be taken or techniques implemented.
5. Identify legislation that provides general authority to agencies to protect and maintain instream flow and advise agencies.
6. Request water planning agencies to review existing authorizations to determine if the agency has adequate legislative authority to maintain instream flow at existing facilities. Where there is not adequate authority and where commitments and economic feasibility permit, the agency, in cooperation with the affected state, shall develop legislative amendments to correct the situation.

Heavy emphasis was given instream flows. Federal agencies were to set a strong example in recognizing and protecting legitimate instream flow needs. If it was deemed necessary, existing water projects would be amended to provide instream flows. The president called upon state governors and Congress to work with Federal agencies to protect fish and wildlife and other values associated with adequate instream flows. Increased cooperation in designing and operating Federal water facilities by all governmental agencies was a prime objective. States, water resources agencies, and individuals and interest groups all were encouraged to participate through this multi-agency Federal approach in working toward a solution to the problem of protecting instream flows.

NATURE OF THE PROBLEM

The issue of instream flows is usually not a clear-cut one of benefits and costs. In the west, the legal water law doctrines and water distribution systems have historically favored out-of-stream uses. Confusion and misunderstanding between various publics and water management and environmental resource agencies are increasing about definitions of, criteria for establishing, and methodologies or means of protecting instream flows. The use of the term "minimum flow" has created problems. Instream flow assessments have traditionally arrived at a single stream flow value—a minimum flow. Such recommendations are usually determined solely from analysis of hydrologic records. Developers have overused this term to describe the ultimate minimum they must leave in the stream.

Clair Stalnaker clarifies these inherent problems in developing adequate instream flows in "Instream Flow MYTHodologies and Water Management Uncertainty" (Cooperative Instream Flow Service Group, U.S. Fish and Wildlife Service, Fort Collins, Colorado. FWS/OBS-79/03, August 1979). He identifies several myths associated with instream flows and suggests bases for their being dispelled to help decision makers better assess related activities and issues of instream flow:

MYTH 1 - **The minimum flow.** A consistent methodology cannot be used to establish the desired minimum flow. A single flow figure is not practical. The minimum flow is not flexible and does not meet all the desired environmental needs.

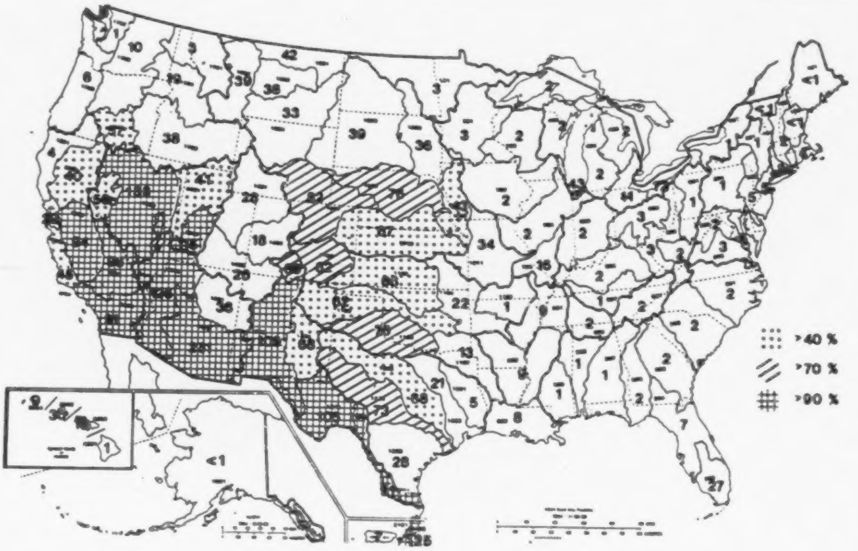
MYTH 2 - **Fish flows satisfy all other instream needs.** Flow requirements make up the total instream flow regime associated with a given stream reach and water yield condition. The more that is known about these situations, the more it is clear that fish flows may not satisfy all uses.

MYTH 3 - **Fish need all of the water.** Maintenance of the fishery may require all of the water none of the time, and the timing of flow needs is a function of management decisions regarding the desired levels of fish production and yield.

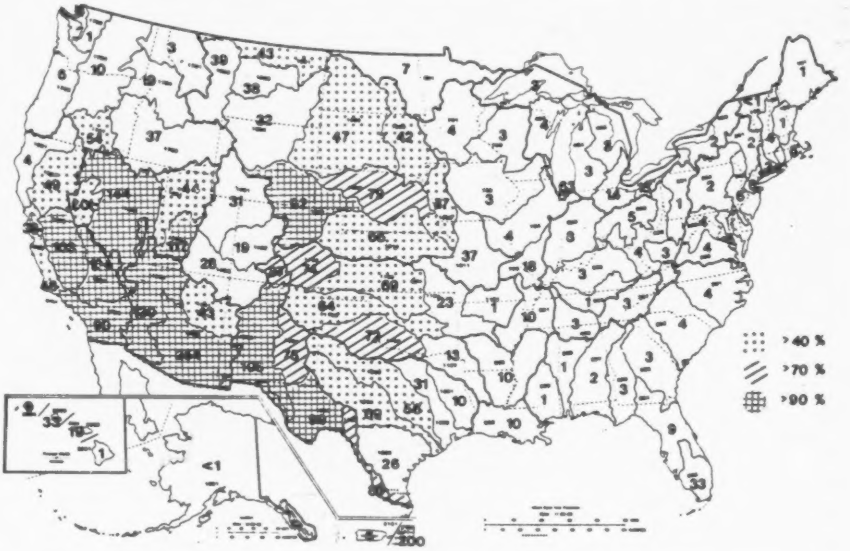
MYTH 4 - **Water quantity is directly related to numbers of fish.** The timing of stream flows (hydrograph and duration curves) and the distribution of the hydraulic characteristics (depth and velocity) throughout a stream reach is not sufficient to describe fish production. Actually, there are four major components of a stream system which determine the productivity of the fishery. These are (1) water quality; (2) watershed inputs in the form of sediments, particulate organic matter, and nutrients; (3) flow regimes; and (4) physical habitat structure.

MYTH 5 - **Instream needs will take away all water rights.** Actually recognition and quantification of instream uses pose no real threat to existing water rights.

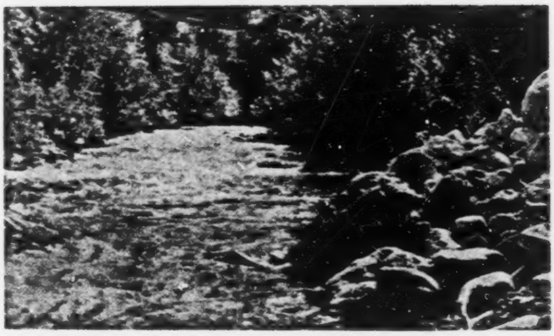
Instream flow advocates must be better informed about legal means to protect instream flows, working within the decision making and administrative processes. The many complex issues concerning water management make it essential that effective negotiation for instream flow protection be implemented at all levels of planning. Through water management the nature of instream uses can be recognized in developing plans for various water supply conditions which equitably distribute the losses among all uses, both instream and out-of-stream, during all times of the year and especially during low-water years.



Assessed 1985 streamflow depletion ratio (%) — average year — indicating relative instream flow conditions.



Assessed 2000 streamflow depletion ratio (%) — average year — indicating relative instream flow conditions.



Logan River, Utah.

LEGISLATIVE ACTS AND EXECUTIVE ORDERS

There is much Federal legislation which provides either directly or indirectly for the protection and maintenance of instream flows for environmental and aesthetic values. These legislative acts and executive orders establish environmental protection and preservation goals and objectives along with standards for their achievement. There are also legislative acts which establish procedural requirements for the consideration and evaluation of environmental needs.

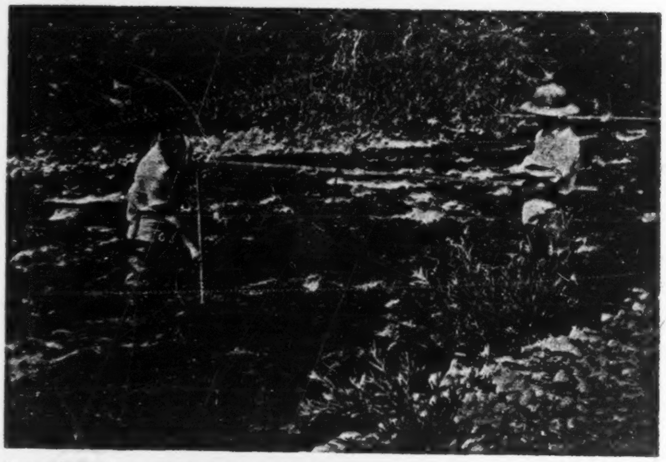
LEGISLATIVE ACTS AND EXECUTIVE ORDERS

P.L. 89-669	Rare and Endangered Species Act
P.L. 95-632	Endangered Species Act Amendments
P.L. 90-452	Wild and Scenic River Act
P.L. 95-217	Clean Water Act of 1977
P.L. 92-532	Marine Protection, Research and Sanctuaries Act
P.L. 93-205	Conservation, Protection and Propagation of Endangered Species
P.L. 93-359	Game Fish Research Act
P.L. 94-579	Federal Land Policy and Management Act of 1976
P.L. 89-90	Water Resources Planning Act (Section 103 establishing Principles and Standards)
E.O. 11990	Protection of Wetlands
P.L. 85-624	Fish and Wildlife Conservation and Resource Development Coordination Act
P.L. 89-72	Federal Water Project Recreation Act
P.L. 91-190	National Environmental Policy Act
P.L. 92-583	Coastal Zone Management Act

All Federal agencies and Federally assisted programs and projects with responsibilities for and related to water and associated land resources must adhere first and foremost to the planning requirements of the Water Resources Principles and Standards, the National Environmental Policy Act of 1969, and related policies.

STRATEGIES FOR RESERVING INSTREAM FLOWS UNDER EXISTING LAWS

The U.S. Fish and Wildlife Service, through its Western Water Allocation Project, contracted with Richard Dewsnup and Dallin Jensen to identify available strategies under state laws, Federal laws, interstate compacts, and water quality laws for reserving instream flows for fish and wildlife. The body of their report[1] contained descriptions of 26 strategies for reserving instream flows under existing laws. These are only a few of many possible strategies but they are among the most promising for obtaining results. These strategies may suggest a starting point.



Logan River, Utah. Width, depth, and velocity are physical instream flow parameters vital to the well-being of aquatic organisms and their habitat.

CONFERRING APPROPRIATIVE WATER RIGHTS

Strategy 1: Obtaining an appropriation from the state water rights agency for fish and wildlife purposes. Applying to an administrative agency for reservation of instream flows for fish and wildlife purposes. Obtaining instream flow rights through appropriations by a state administrative agency.

Strategy 2: Enhancing instream flows through condemnation and reallocation of existing rights.

RESTRICTING APPROPRIATIVE WATER RIGHTS

Strategy 3: Encouraging the state water permit authority to take advantage of discretionary opportunities. Supporting utilization of statutory criteria to protect instream flows. Encouraging imposition of conditions on water use permits to protect instream flows. Encouraging state administrative agencies to promulgate regulations to protect minimum stream flows when water rights are transferred and exchanged.

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[1] Dewsnup, R.L. and Jensen, D.W., "Promising Strategies for Reserving Instream Flows." Western Energy and Land Use Team, Fort Collins, Colorado. FWS/OBS-77/29, October 1977.

LEGISLATIVE, JUDICIAL AND ADMINISTRATIVE CONTROLS

Strategy 4: Obtaining a moratorium on new appropriations.

Strategy 5: Enhancing instream flows through contractual arrangements under state law.

Strategy 6: Adopting interagency agreements, regulations and formal procedures to implement the fish and wildlife coordination act and assist in reserving instream flows.

Strategy 7: Identifying instream flow requirements of endangered species as part of critical habitat determination.

Strategy 8: Inclusion of streams within a wild and scenic rivers system to promote instream flow reservations.

Strategy 9: Legislative designation of important fishery streams to provide for water appropriations.

Strategy 10: Utilizing water quality laws for the purpose of protecting instream flows and enhancing fishery resources.

Strategy 11: Obtaining reservoir space and protective devices for fisheries in dams and reservoirs constructed or licensed under state law.

Strategy 12: Stipulations in new and renewed licenses and permits to reserve instream flows.

Strategy 13: Reauthorization of existing projects to provide for instream flow reservations.

Strategy 14: Utilizing the public trust doctrine to secure instream flows.

RESOURCE PLANNING AND MANAGEMENT

Strategy 15: Participation in statewide water planning to ensure that instream values will be protected with other water uses.

Strategy 16: Emphasizing instream flow needs in Water Resources Council planning programs toward promoting reservations.

Strategy 17: Achieving instream flow reservations by presenting recommendations early in the decision process.

Strategy 18: Utilizing the capability of the United States Geological Survey for gauging and monitoring stream flows.

Strategy 19: Analysis of water rights records as an aid to reserving instream flows.

Strategy 20: Utilizing Federal funding programs in a manner which will emphasize instream flows.

Strategy 21: Use of Federal aid funding to purchase reservoir storage as a means of reserving instream flows.

Strategy 22: Negotiation for reservoirs to facilitate instream flow reservations.

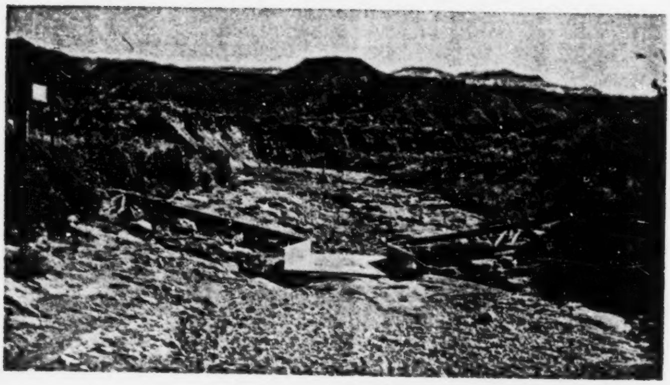
ENGINEERING ALTERNATIVES

Strategy 23: Conveying stored water to downstream users via the stream channel to aid in securing instream reservations.

Strategy 24: Providing for reservation of instream flows by increasing the availability of water for this purpose.

Strategy 25: Coordinated operation of multi-reservoir systems to facilitate instream flow reservations.

Strategy 26: Releases from reservoir sediment storage reserves to promote instream flow reservations.



Coal Creek, Carbon County, Utah. Severe climate limitations, along with agricultural and energy development water demands, synergistically contribute to the disruption of surface flows.

Looking southeast into Settlement Creek Canyon, Utah. Water storage augmented with regulated flow releases can insure adequate instream flow conditions year round.

CONCLUSION

The decision on whether the public or private sector should be responsible for protecting instream uses of water seems to rest on two basic assumptions. The first of these assumptions is that water is a resource which should be allocated in the atmosphere of a free market system. People who believe that water flowing in the stream channel will have a greater value in the future will purchase a share of this resource. This is sort of an investment in which the purchaser can retain his right for the future or sell the right for immediate return on his investment. By this mechanism the water will be preserved into the future.

The second assumption is that flowing water is a public resource and has public values. Individuals or small groups do not have enough power to protect instream flows. Therefore this assumption is used on the state level to pass legislation that protects instream flows through administrative regulations.

Until recently development was thought to be good no matter what the costs. Over the past 20 years this development ideology is dying out and being replaced by the best use and preservation value systems. The demand for public protection of instream flows has increased and instream flows are now generally accepted as a beneficial use.

Private parties have tried to protect instream values in several states. In Colorado, the stream flow through the city of Boulder was protected for aesthetic values by exchange with agriculture users. This involved the negotiation of an exchange of water rights and new release patterns from a reservoir to assure that water flowed through the city at low flow periods.

Washington, Oregon, Montana, Idaho, California, Wyoming, Arizona, Colorado, and North and South Dakota have specific elements in their statutes which provide reservation or protection for instream uses. Utah, New Mexico, and Nevada have no statutory or administrative provisions for the condemnation of existing water rights to reserve instream flows other than by their state game commissions which have the right to secure water rights for the preservation of wildlife. The states seem to be committed to allocating water through private diversion appropriations and public storage projects. This means that in all states the protection of instream values is a politically volatile issue, and in some states it is nearly impossible for the states to protect instream values.

The Reagan administration is still very much involved in the budget and new organization. The present effort mainly concerns revisions and further analysis of water projects, with a higher proportion of water being sold to the energy industry and for municipal and industrial purposes.

A task force on water policy, however, has been established. The task force is made up of the Assistant Secretaries of Interior, Agriculture and Army, along with officials from the Environmental Protection Agency, the White House, and the Office of Management and Budget. They will be recommending water policy reforms to the Cabinet Council on Natural Resources and the Environment. The task force will be headed by Interior Secretary James Watt.

Secretary Watt has reportedly picked several water-related issues for attention by the cabinet council which will be considered by the task force. These include large water projects, coastal zone management, deregulation, barriers to energy development, stream management, and water development. ■

Establishment and Maintenance of Water Rights in the Eastern United States

*William E. Cox**

INTRODUCTION

A water right generally is viewed as a property interest which defines the legal status of the individual water user to take water from a natural source of supply. This right establishes the nature and magnitude of the claim of each user in relation to others sharing the source of supply and therefore provides a basis for resolving conflicts that may arise with other users. The legal principles and procedures for establishment and maintenance of water rights therefore constitute an important component of the institutional framework for water resources management.

Although there are constraints and exceptions that arise out of federal constitutional authority, development of water-rights law primarily has been a function of state government.[a] As in most areas of law where the states have exercised substantial independence, different approaches have been utilized. In fact, the water law of each state is somewhat unique, but the traditional sharing of certain common principles and institutional mechanisms among groups of states makes possible certain categorizations that are normally employed in discussions of water law. This approach is the basis for the conventional separation between eastern and western water law. It must be recognized, however, that differences in the law of two eastern states (or in the law of two western states) in some instances may be equally significant as are differences in the water law of an eastern state when compared to that of a western state.

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In order to analyze procedures for establishing and maintaining water rights in the eastern states, it is necessary to distinguish between two types of water-allocation systems now commonly occurring among the eastern states: the common-law approach and administrative-permitting programs. Basic procedures for legal recognition and enforcement of water rights differ substantially between these approaches.

WATER RIGHTS IN THE COMMON-LAW STATES

Although administrative water allocation now has been adopted in certain cases,[3] some of the eastern states have chosen to continue to rely on traditional common-law doctrines to perform the water-allocation function. In the case of water from streams, the riparian doctrine has been the traditional form of law; with respect to ground water, the absolute-ownership doctrine (also called the English doctrine) and the reasonable-use doctrine (also called the American doctrine) have been the most widely accepted allocation theories among the common-law states.

THE RIPARIAN DOCTRINE

The riparian doctrine recognizes the existence of water rights in the owners of land having contact with a stream or lake, called riparian land, while nonriparian landowners generally have no water rights. In order to examine procedures for establishing and maintaining water rights under this doctrine, attention needs to be directed to the following issues: the origin and nature of the riparian right, the scope and extent of the right, enforcement of the right, and means of transferring the right.

Origin and Nature of the Riparian Right

The origin and nature of the riparian right are intimately related to its association with riparian land. The basic premise of the doctrine is that water rights arise as an incidence of the ownership of land bordered or crossed by a natural stream.[4] This is a primary distinction between riparian and appropriative rights. While the appropriative right may be considered appurtenant to land after establishment, its initial creation is not a result of land ownership alone but requires intentional actions to establish the right such as the application of water to a beneficial use.[5] Since most of the appropriative states have adopted administrative permitting requirements,[6] establishment of the appropriative right also generally involves compliance with prescribed regulatory procedures. On the other hand, the riparian right generally is not subject to administrative control, nor does it depend on water use for legal recognition. Ownership of riparian land generally encompasses an inherent water right which exists whether exercised or not.[7] This fact plays an important role in the operation of the riparian doctrine.

It is well established that the riparian right is a constitutionally protected property right,[8] but it is subject to a special qualification. This qualification was expressed by the Virginia Supreme Court in an early case when it noted that "no one had any property in the water itself, except in that particular portion which he might have abstracted from the stream, and of which he had the possession, and during the time of such possession only."[9] This statement expresses the qualification that the riparian right is a right of use, or usufructuary in nature, and not ownership of the water in a stream.

The fact that the riparian right is usufructuary in nature but can exist even if not exercised distinguishes it from other usufructuary rights such as the appropriative water right which must be exercised in order to be maintained.[10] Although unexercised riparian rights are given legal recognition, there are situations where distinctions are made between the status of exercised and unexercised rights. This issue has arisen in several states where riparian law has been replaced by administrative allocation programs. While riparian rights being exercised by the effective date of a new program are generally recognized and protected, unexercised rights have been abolished in several cases. The courts generally have upheld such action as a valid legislative power.[11] It should be noted that not all states have chosen to abolish unexercised riparian rights when introducing water-law modifications. In California, for example, a 1928 constitutional amendment[12] which restricted all water rights to beneficial use consistently has been interpreted as giving continued recognition to unexercised rights.[13]

Scope and Extent of the Riparian Right

The scope and extent of the riparian right differ between the two alternative theories of riparian rights—the natural-flow theory and the reasonable-use theory. Under the natural-flow theory, each riparian owner is entitled to the natural flow of the stream except as diminished by the domestic uses of upper riparians. Nondomestic uses (usually called artificial or secondary uses) are permitted only to the extent that they do not result in perceptible diminution in natural flow. The occurrence of such diminution gives rise to a cause for legal action even if the lower riparian owner is not adversely affected by the reduction in streamflow. Thus the right of the riparian owner to use water is quite restricted under this theory. The natural-flow theory received wide acceptance during the early history of the United States but has largely been rejected due to its restrictive impact on water-resources development. The natural-flow theory continues to have some vitality in certain states, and remnants of natural-flow language still appear in the opinions of the courts; but the reasonable-use theory has substantially replaced the natural-flow theory as the accepted form of the doctrine in most of the riparian states.[14]

The basic principle of the reasonable-use theory is that the riparian owner has a right to make any use of the waters of a stream that is reasonable in relation to the needs of other riparian landowners. Although the reasonableness requirement places a limit on the amount of adverse impact which legally can be inflicted on other water users, it does not prohibit all adverse effects—only those exceeding some reasonable level.[15] Determination of the reasonable level of impact is the central issue in any application of the reasonable-use concept. "Reasonableness" is not subject to precise description but instead is a relative concept depending on the particular circumstances of each individual case.[16] A fundamental requirement of reasonableness is that a given water use must be compatible with those of other users relying on the same source of supply.[17] A concept of sharing the available supply is a basic aspect of the riparian doctrine. Most uses are given equal consideration in the sharing process,[18] with the exception that individual domestic use is of higher standing than other uses. Satisfaction of domestic needs has been described as the sole purpose for which the entire flow of a stream may be taken.[19] However, municipal use generally is not considered to come within the domestic classification.[20]

Another characteristic of the reasonableness criterion that can affect the continuance of an established water use over time is that it is not a fixed standard but one that can vary over time in response to changed conditions,[21] with the result that the riparian water right can also vary over time. In fact, some courts have held improper the setting of a fixed magnitude for a riparian right not subject to variation with time.[22] This variation can occur over the course of a year as streamflow varies with the seasons. Variation in magnitude of the water right can also occur within a long-range context. For example, variation in streamflow from year to year creates a varying resource for application of the sharing requirement, and droughts must be shared according to the same principles that apply to normal flows.[23] Another potential source of variation consists of changes in water-use patterns. A basic factor in this regard is the possibility that dormant rights may be exercised at a future date. Since unexercised riparian rights continue to attach to riparian property and are not extinguished by simple nonuse,[24] the initiation of new uses requiring adjustment in previous uses is always a potential occurrence.[25] In the extreme case, it is conceivable that a previously reasonable use could become unreasonable due to substantial changes in water-use practices or other factors. Thus the riparian right is subject to an inherent uncertainty due to its means of definition.

Enforcement of the Riparian Right

Due to the common-law status of the riparian right, administrative procedures for enforcement are generally absent, and judicial enforcement by means of the individual lawsuit is the standard mechanism. The full range of civil-law actions is potentially available to the party whose riparian rights are violated by another.

Both actions at law and suits for injunction can be appropriate remedies for infringement of the riparian right. The general principle that equitable remedies should be limited to situations where actions at law are inadequate applies to water-rights disputes equally as in other areas of law. Injunction may be an appropriate means to prevent an anticipated violation of the riparian right or to restrain a recurring violation of the right.[26] The right to an action for damages generally does not arise under the reasonable-use concept of the doctrine until a riparian owner is adversely affected. While diminution of natural flow is itself violation of a legal right under the natural-flow theory, such diminution in the absence of actual injury is not legal injury and therefore does not create a right of action under the reasonable-use concept.[27]

The need for prospective clarification of riparian rights can be met through actions for declaratory judgment or quieting title. The declaratory-judgment action provides a mechanism for adjudication of uncertain or threatened rights prior to occurrence of overt wrongful actions; however, a substantial controversy must exist since such actions are not applicable where only hypothetical or speculative questions concerning rights are involved.[28] Quiet-title actions are appropriate mechanisms where title adjudication is needed. Since the purpose of this action is the determination of existing title to property, it provides a forum for assessment of the validity of adverse claims affecting title. This mechanism therefore is useful to the holder of riparian rights challenged by adverse claims of other parties.[29]

Proceedings for determination of water rights in the common-law eastern states in general appear to be of narrower scope than such proceedings in the western states. Although eastern judicial proceedings involving riparian rights sometimes involve multiple parties, the absence of special mechanisms for adjudicating such rights is likely to have the effect of keeping such proceedings at a limited scale. The existence in the western states of special administrative proceedings and legislative provisions for special judicial proceedings[30] creates a significantly greater potential for water-rights conflicts to expand into general adjudications of water rights in a particular source of supply.

Transfer of the Riparian Right

Since riparian rights exist as an incidence of the ownership of riparian land, they generally are transferred with land. The rule is that, in the absence of an explicit provision in the instrument of conveyance, the seller of riparian property generally relinquishes riparian rights upon conveyance of the land while the purchaser acquires such rights.[31] Riparian rights are widely recognized as being severable from land, however, whenever this intention is clearly expressed,[32] regardless of the fact that they originally exist as an incidence of ownership of riparian property. Thus the riparian right can be conveyed as an independent property interest to another party while the riparian land is retained, or the land can be conveyed while the water right is retained.

Although the severability of riparian rights is generally recognized, special institutional mechanisms for separate administration of such independent water rights usually do not exist. Rather, such conveyances are incorporated into the system for establishing and maintaining title to realty. Provisions to effect separation of riparian rights from land therefore generally exist as deed provisions.[33] In order for the severance of a riparian right to be enforceable against a successor in title to the land to which the right originally attached, the action to sever must meet applicable procedural requirements such as recordation.[34] Where partial water rights are severed, the holder is protected against water use by owners of the servient estate which interfere with the purpose of the severed right, but use which does not interfere with the severed right is permissible.[35] Conflicts involving the extent or other aspects of severed water rights are resolved by application of standard principles of deed construction.[36]

Although the riparian right can be severed and transferred independently of land, the extent of the right transferred is subject to restrictions. Special rights conveyed to riparian owners by legislation may not be transferable. For example, the Virginia Supreme Court has held that a statutory right of a riparian owner to make certain fills adjacent to riparian property cannot be conveyed as a part of severed riparian rights.[37] More fundamentally, the severed right may continue to be subject to basic restrictions of the riparian doctrine such as those concerning place of use. Application of the general principle that the seller can convey only those rights that he possesses suggests that the purchaser will be subject to all the restrictions affecting the seller. Since the riparian owner cannot use water on nonriparian land, he generally would not be able to convey such right to another. This issue appears to have received surprisingly little attention in the courts in view of its potential significance.

A few cases have considered the right of the riparian owner to convey recreational privileges to nonriparians. In a Connecticut case involving an attempted extension of recreational rights in a lake to owners of nonriparian lots, the court stated that "any attempted transfer of the right made by a riparian to a nonriparian proprietor is invalid."[38] The Supreme Court of Michigan in a case involving the granting of recreational rights to nonriparians appeared to accept the principle that riparian rights could not be subject to such transfers,[39] but the court viewed the recreational rights in question as constituting an easement of access. The court indicated that the reasonableness of the impact from the additional activity should be the primary criterion for determining its validity under the riparian doctrine.[40] The final decision in the case upon its second appearance before the state supreme court, however, was not based on the reasonableness of the activity but on the extent to which the project had been allowed to progress by the time legal opposition was expressed. The court held that the extent of investment already made had created a situation where completion could not be forbidden equitably.[41]

An early California decision[42] provides an example of a case considering restrictions on the transfer of riparian rights involving withdrawal of water. The case involved a conflict between the holder of severed riparian rights and a riparian owner whose predecessor in title had deeded all the water rights pertaining to the land to the holder of the severed rights. The court upheld the severed right against the owner of the property from which the right had been severed, but a concurring opinion expressed in the form of dicta the view that the holder of the severed right had no right against other riparian owners.[43] The concurring opinion suggested that absolute rights to the use of the water of the lake could be created through acquisition of the water rights of all the riparian landowners. While this solution may not be feasible except in special circumstances, it does offer the possibility of an unfettered right to use water since no parties with standing to complain would remain.

A special method of riparian rights transfer which is not based on active compliance of the previous owner is the process of prescription. The riparian right normally cannot be lost by simple nonuse, but it can be lost where adverse use by another party occurs under conditions that give rise to a presumption of a grant. The usual condition necessary for creation of a prescriptive right in another party consists of use which is "adverse under claim of right, open, notorious, continuous, uninterrupted, and for the period of prescription."[44] The most common period of prescription is 20 years although both shorter and longer periods have been recognized.[45] It is well established that riparian rights may be transferred through the prescriptive process.[46]

An important issue regarding the establishment of the prescriptive right is the determination of the date at which the prescriptive period begins to run. The action necessary to initiate the prescriptive period differs between the natural-flow and reasonable-use theories since the definition of a water-rights violation differs. Under the natural-flow concept, the right of the lower riparian owner is violated whenever the natural flow is diminished for nondomestic purposes, and a cause of action can arise at that point even if injury is not produced. Since this point marks the beginning of legal adversity, it can signal the initiation of the prescriptive period.[47]

The resulting need under the natural-flow theory for precautionary actions to protect water rights from loss through prescription can be detrimental to full utilization and development of water resources. In response to this problem, New York has adopted legislative modifications[48] of its riparian law which traditionally gave acceptance to the natural-flow concept.[49] These modifications provide that any alteration in a watercourse or lake is lawful unless it causes harm as defined in the statute and that "[n]o action for nominal damages or for any injunction shall be maintainable because of such an alteration. . . ."[50]

In the case of the reasonable-use concept, violation of the riparian right does not necessarily occur with diminution of streamflow but depends on unreasonable interference with a water use. Therefore the prescriptive period does not begin to run until such interference occurs.[51] One consequence of this fact is that prescriptive rights cannot be acquired against unused water rights since interference is not feasible. Where the riparian doctrine in a particular state contains elements of the natural-flow concept together with the reasonable-use concept, however, the requirement for actual interference with water use as a condition for initiation of the prescriptive period may not be imposed strictly.

A possible example of this situation is given by the Virginia decision Town of Gordonsville v. Zinn.[52] To put this decision in context, it should be noted that certain Virginia cases contain language of the natural-flow theory[53] although the state appears to have adopted the reasonable-use theory.[54] The Gordonsville case involved a suit for injunction by the town to prohibit another landowner from using water from a small, nonnavigable stream that supplied municipal reservoirs. Although the court found that municipal use at a nonriparian location was not recognized as valid under the riparian doctrine, it held that the town had acquired prescriptive water rights against all lower landowners due to its adverse use for longer than 30 years. Since the court made no reference to specific injury to downstream landowners, it appears that interruption of natural flow for the prescribed period may have been sufficient to establish the prescriptive right. This case therefore serves as an illustration of the potential uncertainty associated with the prescriptive process as applied to riparian rights.

Transfer of riparian rights also can be accomplished through the process of eminent-domain condemnation. Since the right is severable from land, it can be condemned independently of riparian property.[55] The scope of water-rights condemnation in the eastern states appears somewhat more restricted than in the western states. The primary distinction is the potential in some of the appropriative states for water-use preferences established by legislation to be implemented through condemnation of inferior uses by preferred uses.[56] The law regarding this issue is not well developed, but there appears to be some potential for broader use of condemnation than under eastern law where water-rights condemnation is largely limited to traditional public purposes such as municipal water supply. The need for public water suppliers to eliminate restrictions such as limitations on place of use is likely to require condemnation or other acquisition of all affected water rights. This burden is lessened by the general willingness of the courts to allow inverse condemnation proceedings if water-rights infringements occur after initiation of water-supply operations.[57] This approach mitigates some of the uncertainty regarding the extent of water rights under the riparian doctrine and allows public suppliers to construct necessary facilities and initiate withdrawals prior to final resolution of water-rights issues.

COMMON-LAW GROUND-WATER RIGHTS

Establishment of a legal right in ground water under eastern law generally has first required that the water involved be classified as either an "underground watercourse" or as "percolating ground water."[58] Due to the difficulties of overcoming the burden of proof imposed on the party alleging the existence of an underground watercourse, most underground water is classified as percolating; thus the distinction between underground watercourses and percolating water, in addition to being based largely on scientific misconceptions, is also largely theoretical.

Special doctrines of water rights distinct from surface-water law apply to water considered percolating ground water. In the East, the two principal doctrines traditionally applied have been those of absolute ownership and reasonable use. The absolute-ownership doctrine, also known as the English doctrine due to its origination in Great Britain, is based on the concept that each landowner has complete ownership and control over water underneath his land just as he does in the case of soil or rock. Therefore each landowner has an unlimited right to use ground water or to interfere with his neighbor's supply through normal land development activities, subject only to general prohibitions against waste, malicious interference, or negligence.[59] Although the doctrine refers to absolute ownership, it does not create an enforceable water right since no right of legal action exists for injury produced by the activities of others. Thus the doctrine constitutes a simple rule of capture. The absolute-ownership doctrine found considerable acceptance in the United States during the early development of ground-water law but has subsequently been rejected by most of the states.

The reasonable-use doctrine, also known as the American doctrine, developed in the United States as a response to the excesses of the absolute-ownership doctrine. This doctrine is the predominant form of common law presently applied to ground water in the eastern states. Under the reasonable-use doctrine, the landowner is viewed as having the right to make any reasonable use of ground water on the overlying land, or the right to reasonably develop property, although interference with the water supplies of others results.[60]

One of the primary distinctions between the reasonable-use and absolute-ownership doctrines concerns restrictions on place of water use. While the absolute-ownership doctrine places no restriction on place of water use and permits export for use elsewhere, one of the general principles of the reasonable-use doctrine is that water use is limited to the overlying land. This principle has seen its greatest application in situations where municipalities attempt to pump water from wells located on outlying parcels of land for piping into urbanized areas.[61]

With regard to use of water on the overlying land, most of the reasonable-use decisions suggest that the rights of the landowner under the reasonable-use doctrine do not differ significantly from those existing under the absolute-ownership concept. The cases generally interpret "reasonable use" to encompass any traditional water or land use and do not impose restrictions based on a sharing requirement as exists in the riparian doctrine.[62] Thus the apparent similarity between this ground-water doctrine and the riparian doctrine suggested by common usage of the "reasonable use," term does not exist in reality. However, not all of the cases that conceivably could be classified as reasonable-use decisions refuse to place limits on overlying use. Although relatively few in number, cases can be found where the relative rights of adjacent ground water users were weighed and a decision reached which gave recognition to the interests of both parties.[63] Due to the fact that such decisions are fundamentally different from the majority of reasonable-use decisions, these cases have been viewed by some analysts as examples of an eastern correlative-rights doctrine similar to that employed in California.[64]

A basic characteristic of the water right under either the absolute-ownership or reasonable-use doctrine is the lack of security regarding maintenance of a water use over time. At least with regard to onsite use, both doctrines traditionally have been interpreted essentially as rules of capture, and the established user has no protection against subsequent ground water developers except to drill his own well deeper.[65]

Although the common-law doctrines applicable to percolating ground water are based on substantially different allocation principles, these doctrines share many of the characteristics of the riparian doctrine in terms of such factors as enforcement and transferability. The inherent insecurity of water rights under these doctrines combines with the limitations of the common-law approach to create significant problems regarding establishment and maintenance of water rights. While these doctrines are workable under low levels of ground-water development, they do not appear to provide a sound basis for water allocation under conditions of competition for ground water. As one indication of this fact, the eastern states have shown a greater tendency to replace ground-water law with administrative allocation systems than to replace existing surface-water law.[66]

WATER RIGHTS IN THE ADMINISTRATIVE ALLOCATION STATES

As a result of perceived deficiencies in the common-law water-allocation systems traditionally employed in the eastern states, several of these states have adopted administrative allocation programs. These changes in water law have been occurring over a significant period of time. An example of an early change involving a major departure from the traditional common-law approach occurred in 1933 when the state of Maryland adopted a water-use permitting system that encompassed both surface and ground water.[67] As is typical of many cases involving water-law changes, adoption of the Maryland statute was preceded by several years of severe drought. A substantial number of other changes in water-allocation law now have been adopted, and certain eastern states currently are evaluating the possibility of making such changes.[68]

Although the eastern states utilizing administrative allocation share certain common factors, the individual programs differ widely with regard to several issues. One such issue consists of the types or sources of water covered by the program. Some states have adopted a comprehensive allocation program covering both surface and ground water.[69] Others apply administrative controls to either surface or ground water while leaving the allocation function for the other source of water to be performed within the traditional common-law system.[70] Still others have applied independent administrative controls to surface and ground water.[71]

Extent of geographical coverage of controls is another significant variable. Controls have been implemented on a river-basin basis encompassing all or portions of several states, on a statewide basis, and within special management districts encompassing designated portions of individual states. Allocation by river-basin authorities has occurred as a result of two federal-interstate compacts. The first of these is the Delaware River Basin Compact which was ratified by the states of Delaware, New Jersey, New York and Pennsylvania and given federal consent in 1961. The other interstate commission to be granted water-allocation powers was created by the Susquehanna River Basin Compact developed by the states of Maryland, New York and Pennsylvania. The Susquehanna Compact was modeled after the Delaware compact; both bestow broad water management authority on a basin commission which includes water-use controls.[72] Examples of statewide controls implemented by individual states include such states as Florida,[73] Kentucky,[74] Maryland[75] and Mississippi.[76] The Florida approach is somewhat unique in that it calls for water-use controls to be implemented primarily by five regional water management districts rather than by a central state agency. The special management district approach has been implemented in other states such that only designated portions of the state are subjected to controls. The district approach in Mississippi, for example, is applied to ground water[77] while statewide administrative controls apply to surface water.[78] Controls applicable to both surface and ground water are applied on a district basis in North Carolina[79] while only ground water is subject to such controls in Virginia.[80]

This variation among state water allocation programs limits the potential to generalize concerning the establishment and maintenance of water rights under administrative allocation systems, but certain common characteristics exist regardless of variability in program detail. Three such features of significance to establishment and maintenance of water rights include administrative procedures for defining and granting legal recognition to water rights, mechanisms for protecting established water users from new users, and impact on the status of water rights.

PROCEDURES FOR DEFINING WATER RIGHTS

A characteristic of administrative water allocation which constitutes a basic distinction from the common-law approach is its more precise definition of water rights. Administrative programs generally involve special procedures for establishment and administration of water rights, thereby ending the primary reliance traditionally placed on land-title systems under common-law allocation. In place of judicially enforced requirements such as the reasonableness criterion of the riparian doctrine, administrative allocation typically imposes a permitting requirement through which water rights are defined in terms of quantity and other dimensions of use.[81] The water-use permit becomes the exclusive basis for legal recognition of a water right, with the exception of uses exempted from the permit requirement.

With regard to vested common-law rights existing at the time the administrative program is initiated, a process for conversion into water-use permits is usually established. The requirements of the Virginia administrative allocation program, which utilizes the special management district approach, provides an illustration of this process. Vested rights recognized in this legislation include ground-water uses in existence on the date a management area is designated, intended uses where wells are under construction, and uses in existence within the two-year period prior to area designation. To be given legal acknowledgment within the administrative allocation program in effect in such designated areas, ground-water uses in these categories must be registered with the administering agency and receive a certificate of ground-water right. Such use is presumed abandoned unless a registration statement is filed within six months after area designation; however, this presumption of abandonment is subject to rebuttal within a one-year period by means of specified procedures.[82]

Since the administrative permitting process defines the water right in terms of the conditions of water use, the right generally is less flexible than under common law. Provisions are generally included for changes in water use, but such changes normally require approval of the administering agency in the form of permit modifications.[83]

PROTECTION OF ESTABLISHED WATER USERS

Administrative water-allocation programs usually attempt to increase the security of established water rights by controlling the initiation of new water uses. One of the most significant sources of uncertainty under the riparian doctrine and common-law doctrines of ground water rights is associated with the exercise of previously dormant rights such that existing uses are adversely affected. Since one of the usual objectives of administrative permitting is protection of established water users, consideration of adverse effects on such users is a basic factor in determining whether to issue a permit for initiation of a new use.[84]

But the effectiveness of measures to reduce uncertainty by controlling the initiation of new uses can be reduced by exemptions to the administrative-permitting requirement. Exemption of certain types of water use are included in most administrative allocation programs. An essentially universal exemption consists of small uses which have minor impact on water supplies. In some cases, however, categorical exemptions are not limited to small uses but include some of potentially large magnitude. Such provisions constitute an important regulatory loophole which can create substantial uncertainty relative to maintenance of established water rights. This problem is common to several of the administrative allocation programs in effect in the eastern states.

The Kentucky water-allocation system serves as an illustration of potential conflict associated with a generous exemption provision. Exemptions under the Kentucky legislation include domestic users, agricultural users and irrigators, uses exempted by administrative regulation, certain specified steam-generating plants, and water injected underground in connection with oil and gas production.[85] Existing permit holders are protected from new regulated users by a provision which states that a new permit will be granted only if the proposed use "will not be detrimental to the . . . rights of other public water users."[86] However, the legislation does not clearly define the relative standing between permit holders and nonregulated uses. The existence of substantial exemptions and the failure to define the relative rights of water users during shortages have been major focal points of criticism of the Kentucky water-use legislation.[87]

Virginia provides a second useful example of the potentially detrimental impact of exemptions on the security of water rights under an administrative allocation system. Exempted from water-use regulations that apply within specially designated management areas is "[t]he use or supplying of ground water for agricultural and livestock watering purposes, for human consumption or domestic purposes, or for any single industrial or commercial purpose in an amount not exceeding fifty thousand gallons a day."[88] Although the exemption provision does not make specific reference to municipal use or public water supply, the Virginia Attorney General has determined that municipal withdrawal for human consumption and other domestic purposes is exempt without regard to quantity as in the case of individual use for these purposes.[89] Municipal withdrawals for single industrial and commercial purposes exceeding the 50,000 gallon per day limitation theoretically are subject to the permitting requirement. However, regulation of municipal withdrawals on a selective basis poses problems of administrative feasibility since individual withdrawals are likely to be commingled with water from several sources. Thus, it is doubtful as to whether municipal withdrawal of ground water can be effectively regulated under the existing legislation. This management problem is especially significant due to the fact that expansion in municipal water supply is expected to be the principal growth in water use in at least one of the state's two designated ground-water management areas.[90]

IMPACT ON THE STATUS OF WATER RIGHTS

In addition to the insecurity associated with excessive exemptions from administrative programs in some of the eastern states, another more fundamental source of insecurity in maintaining water rights appears to be a common feature of these programs: the transformation of water rights from a relatively permanent property interest to a less absolute form of conditional permission from the state to use water. With the exception of Mississippi which adopted the western concept of prior appropriation as the basis for administrative controls over surface water use, the eastern states adopting administrative controls generally have tended to decrease the significance of basic water-law doctrines and to rely more heavily on administrative discretion as an integral aspect of water-use decision making. Many of the newer water-use permit programs, in an attempt to give greater protection to the public interest, involve comprehensive integration of discretionary authority into water-use controls. This authority can encompass such factors as special restrictions to be applied during water shortages and limits on the duration of water rights established under the permit program.

Kentucky water-use legislation provides an example of special limitations imposed on water rights established under administrative allocation. The legislation states that "[s]uch permits represent a limited right to use and do not vest ownership nor an absolute right to withdraw or use the water."[91] While the full meaning of this provision is not clear, another more specific restriction is imposed on permit holders. The act provides that during droughts or other emergency situations, the administering agency may suspend the operation of the permit system and allocate available water supplies on some other basis.[92]

Florida water-use legislation provides another example of an administrative water-allocation program which places special limitations on water rights recognized. Under the statute, permits may be issued for any period not exceeding twenty years, or for periods of up to 50 years in the case of public water suppliers.[93] Provision is made for revocation of a permit for a number of reasons, including nonuse of the water supply allowed by the permit for a period of two years or more unless the user can prove that the nonuse was due to extreme hardship caused by factors beyond his control.[94] The legislation mandates the formulation of a plan to be implemented during periods of water shortage.[95] As part of this plan, a system of permit classification must be developed, and the administering agency "may impose such restrictions on one or more classes of permits as may be necessary to protect the water resources of the area from serious harm and to restore them to their previous condition."[96] Under emergency conditions, orders may be issued "requiring that such action, including but not limited to apportioning, rotating, limiting or prohibiting the use of the water resources of the district, be taken" as deemed necessary for meeting the emergency.[97]

This approach which significantly restricts the scope of the water right is distinct from that taken in traditional western permit programs through which the appropriation doctrine is implemented. Although the western programs involve administrative decision making, significant property rights relatively independent of administrative officials are recognized in the individual appropriators. For example, appropriative rights generally are considered to exist in perpetuity and cannot be revoked by the state except through limited procedures.[98] The underlying philosophy of such programs is that the highest and best use of water is promoted by a system of broadly defined water rights relatively free from administrative discretion. In this view, administrative decision making is a less desirable mechanism for achievement of optimum water use than is private decision making based on relatively certain water rights defined to exist in perpetuity. The certainty associated with such permanent rights is seen as encouraging investment in water-using facilities and providing a basis for market transfer of water rights to higher and better uses whenever they arise.[99] Of course there are those who would question whether the appropriative system does in fact accomplish this objective in view of such problems as constraints on water-rights transfers.[100] In any event, the eastern permit programs generally are based on a high degree of state control, with the result that the emphasis placed on property rights in water is decreased.

CONCLUSION

Eastern water rights traditionally have been characterized by two related factors: their common law nature and their close association with land ownership. Due to their nature and method of enforcement, eastern water rights generally have not been precisely defined in terms of such basic dimensions as quantity. Administration has tended to be passive in nature, consisting largely of judicial resolution of specific water-use conflicts. Thus water rights in general have occupied a less prominent role in eastern law than have their counterparts in the law of the western states.

This distinction between eastern and western water rights has resulted in large part from differences in the ratio of water demand to water supply between the two sections of the country; therefore it would appear likely that differences between eastern and western water rights would diminish as the demand/supply ratios become more similar. This trend is evident to some extent. A tendency to replace common-law water rights with administrative allocation systems is reflected in developments in several eastern states. A basic aspect of these water-law modifications is the introduction of more definitive procedures for establishing and maintaining water rights, including administrative arrangements to replace the courts as the primary water-allocation mechanisms.

The eastern states do not, however, indicate any appreciable tendency to accept the substance of western law for defining water rights. There is one similarity between the eastern and western administrative allocation programs: the established water user is given some degree of protection against the actions of prospective users. Beyond this similarity, however, the two approaches are basically distinct. Where the western water right is based on predetermined principles for resolving such issues as conflicts during times of water shortage with only the exercise of essentially ministerial functions by program administrators, the eastern water right is likely to be subject to the direct exercise of administrative discretion under several conditions.

Although the limitation of individual water rights by provision for exercise of administrative discretion is more pervasive in eastern water allocation programs, the western states have shown some tendency to restrict private water rights to allow greater state control. For example, the state of Washington has adopted the concept of time-limited water-use permits.[101] The movement to restrict water rights is likely to continue to expand as part of a general trend affecting property rights in general. Greater concern over environmental quality and other aspects of the public interest associated with natural-resource use has resulted in a less absolute view of property rights than that existing but a few years ago. Water rights cannot be expected to have immunity from this general evolutionary development in social institutions, either in the eastern or western states.

[To appear in the next issue, The Initiation of New Water Rights in the Western States, by Raphael J. Moses and Timothy J. Beaton.]

FOOTNOTES

[1] See Clark, ed., Waters and Water Rights § 53.

[2] For an analysis of federal-state relations in water management, see Id. vol 2, § 100.

[3] Several of these programs are used as examples in the following sections of this paper.

[4] Tiffany Real Prop § 722 (3rd Ed).

[5] Establishment of the appropriative right is considered in Clark, supra note 1, § 409.

[6] See Clark, supra note 1, § 409.

[7] See 93 CJS, Waters, § 5 et seq.

[8] See, e.g., Yates v. Milwaukee, 77 US (10 Wall) 497, 504 (1870).

[9] Mumpower v. City of Bristol, 90 Va 151, 17 SE 853 (1893).

[10] For a discussion of procedures through which unused appropriative rights can be lost, see Clark, supra note 1, § 413.

[11] See, e.g., Village of Tequesta v. Jupiter Inlet Corp., 371 So 2d 663 (Fla 1979); Knight v. Grimes, 80 SD 517, 127 NW2d 708 (1964); Southwest Engineering Co. v. Ernst, 79 Ariz 403, 291 P2d 764 (1955); State ex rel. Emery v. Knapp, 167 Kan 546, 20 P2d 440 (1949).

[12] Cal Const art XIV, § 3.

[13] See, e.g., Tulare Irr. Dist. v. Lindsay-Strathmore Irr. Dist., 3 Cal 2d 489, 45 P2d 972 (1935); In re Waters of Long Valley Creek, 84 Cal App 3d 140, 148 Cal Rptr 488 (1978).

[14] For a discussion of the natural flow theory, see Farnham, The Improvement and Modernization of New York Water Law Within the Framework of the Riparian System, 3 Land & Water L Rev 377, 382 (1968).

[15] See Rancho Santa Margarita v. Vail, 11 Cal 2d 501, 81 P2d 533, 563 (1938). Citation of California decisions in support of basic riparian concepts is a reflection of the fact that the riparian doctrine, although generally considered as part of eastern water law, has undergone some of its most intensive development in this western state which employs both riparian and appropriative law.

[16] See, e.g., Hazard Powder Co. v. Somersville Mfg. Co., 78 Conn 171, 61 A 519 (1905).

[17] See, e.g., Arminius Chemical Co. v. Landrum, 113 Va 7, 73 SE 459 (1912).

[18] See, e.g., Harris v. Brooks, 225 Ark 436, 283 SW2d 129 (1955).

[19] See Evans v. Merriweather, 3 Scam (4 Ill) 492 (1842).

[20] Pernell v. Henderson, 220 NC 79, 16 SE2d 449 (1941).

[21] See, e.g., Seneca Consol. Gold Mines Co. v. Great Western Power Co. of California, 209 Cal 206, 287 P 93 (1930).

[22] See Prather v. Hoberg, 24 Cal 2d 549, 150 P2d 405 (1944).

[23] See Evans, supra note 19.

[24] See 93 CJS, Waters, § 13.

[25] For discussion of this point, see Thomas v. La Cotts, 222 Ark 171, 257 SW2d 936, 940 (1953).

[26] See 93 CJS, Waters, § 14(b); generally see 43 CJS, Injunctions.

[27] For an often quoted statement regarding the necessity of injury, see Stratton v. Mt. Hermon Boys' School, 216 Mass 83, 103 NE 87, 89 (1913).

[28] For a general discussion of declaratory judgments, see 26 CJS, Declaratory Judgments.

[29] For a general discussion of actions for quieting title, see 74 CJS, Quieting Title.

[30] See Water Rights-Finality of General Adjudication Proceedings in the Seventeen Western States, 1966 Utah L Rev 152 (1966).

[31] See 93 CJS, Waters, § 206.

[32] Id. § 207(b).

[33] Id. § 208.

[34] For a general discussion of recordation requirements, see Tiffany, supra note 4, § 1257 et seq.

[35] See 93 CJS, Waters, § 210.

[36] See Tiffany, supra note 4, § 977 et seq.

[37] Commonwealth, Marine Resources Commission v. Forbes, 214 Va 109, 197 SE2d 195 (1973).

[38] Harvey Realty Co. v. Borough of Wallingford, 111 Conn 352, 150 A 60 (1930) at 63.

[39] Thompson v. Enz, 379 Mich 667, 154 NW2d 473, 483 (1967).

[40] Id. at 484.

[41] Thompson v. Enz, 385 Mich 103, 188 NW2d 579, 580 (1971).

[42] Duckworth v. Watsonville Water & Light Co., 158 Cal 206, 110 P 927 (1910).

[43] Id. at 932.

[44] Tiffany, supra note 4, § 1191.

[45] Id. § 1133.

[46] Id. § 1194.

[47] See cases cited in Farnham, Modernization and Improvement of New York's Riparian Law 9–14 (1974).

[48] NY Envir Conserv Law § 15–0701.

[49] See Farnham, supra note 47.

[50] NY Envir Conserv Law § 15–0701(1).

[51] See Clark, supra note 1, § 620.2.

[52] Town of Gordonsville v. Zinn, 129 Va 542, 106 SE 508 (1921).

[53] See, e.g., Hite v. Town of Luray, 175 Va 218, 8 SE2d 369 (1940).

[54] See Gordonsville, supra note 52.

[55] See, e.g., Clear Creek Water Co., Inc. v. Gladeville Improvement Co., 107 Va 278, 58 SE 586 (1907).

[56] See Gross, Condemnation of Water Rights for Preferred Uses—A Replacement for Prior Appropriation?, 3 Willamette LJ 263 (1965).

[57] See, e.g., Town of Purcellville v. Potts, 179 Va 514, 19 SE2d 700 (1942).

[58] A frequently cited case considering this distinction is Clinchfield Coal Corp. v. Compton, 148 Va 437, 139 SE 308 (1927).

[59] For a general discussion of this doctrine, see Clark supra note 1, § 52.2(B).

[60] Id.

[61] See, e.g., Meeker v. City of East Orange, 77 NJL 623, 74 A 379 (E&A 1909).

[62] See Davis, Wells and Streams: Relationship at Law, 37 Mo L Rev 189, 202 (1972).

[63] See, e.g., MacArtor v. Graylyn Crest III Swim Club, Inc., 41 Del Ch 26, 187 A 417 (1963); Jones v. Oz-Ark-Val Poultry Co., 228 Ark 76, 306 SW2d 111 (1957).

[64] See Davis supra note 62 at 203.

[65] See Couch v. Clinchfield Coal Corp., 148 Va 455, 139 SE 314 (1927).

[66] Virginia is an example of an eastern state to adopt an administrative ground water allocation program (Virginia Ground Water Act of 1973, Va Code Ann § 62.1–44.83 et seq.) while continuing a common-law allocation system for surface-water allocation.

[67] Md Acts, ch 526, sec 1 (1933), now Md Ann Code § 8–801 et seq.

[68] See, e.g., NC Sess Laws, ch 1019 (1979); Va Acts of Assembly, HJR 236 (1977) as modified and continued by id. SJR 1 (1978), id. SJR 36 (1980), and id. SJR 152 (1981).

[69] See, e.g., Md Ann Code § 8–801 et seq.

[70] See note 65 supra.

[71] See, e.g., Miss Code Ann § 51-3-1 et seq. and Miss Code Ann § 51-4-1 et seq.

[72] See Muys, Interstate Water Compacts: The Interstate Compact and Federal Interstate Compact 143, 193 (1971).

[73] Florida Water Resources Act of 1972, Fla Stats Ann § 373.013 et seq.

[74] Ky Rev Stats § 151.010 et seq.

[75] See note 66 supra.

[76] Miss Code Ann § 51-3-1 et seq.

[77] Miss Code Ann § 51-4-1 et seq.

[78] Id. § 51-3-1 et seq.

[79] Water Use Act of 1967, NC Gen Stats § 143-215.13 et seq.

[80] Virginia Ground Water Act of 1973, supra note 66.

[81] See, e.g., Ky Rev Stats § 151.170(1).

[82] Va Code Ann §§ 62.1-44.93, 62.1-44.99.

[83] See, e.g., Fla Stats Ann § 373.239(2).

[84] See, e.g., Va Code Ann § 62.1-44.100(d), (e).

[85] Ky Rev Stats § 151.140.

[86] Id. § 151.170(2).

[87] See Ausness, Water Use Permits in a Riparian State: Problems and Proposals, 66 Ky LJ 191 (1977).

[88] Va Code Ann § 62.1-44.87.

[89] Letter from A. Miller, Attorney General of Va., to T. McNamara, Chairman, Virginia State Water Control Board (Jan. 8, 1976).

[90] The two designated areas include the southeastern corner of the state consisting of that area of the Atlantic Coastal Plain in Virginia lying south of the James River and Virginia's Eastern Shore.

[91] Ky Rev Stats § 151.170(1).

[92] Id. § 151.200.

[93] Fla Stats Ann § 373.236.

[94] Id. § 373.243.

[95] Id. § 373.246.

[96] Id. § 373.246(3).

[97] Id. § 373.245(7).

[98] See Clark, supra note 1, § 409.

[99] See Trelease, Policies for Water Law: Property Rights, Economic Forces, and Public Regulation, 5 Natural Resources J 1 (1965).

[100] See Carlson, Has the Doctrine of Appropriation Outlived Its Usefulness? 19 Rocky Mt ML Inst 229 (1974).

[101] Wash Admin Code § 173-596-040 (1981). For a discussion, see Anderson and Rogers, Time-Limited Water Permits: Legal and Economic Considerations, 12 Gonzaga L Rev 193 (1977).

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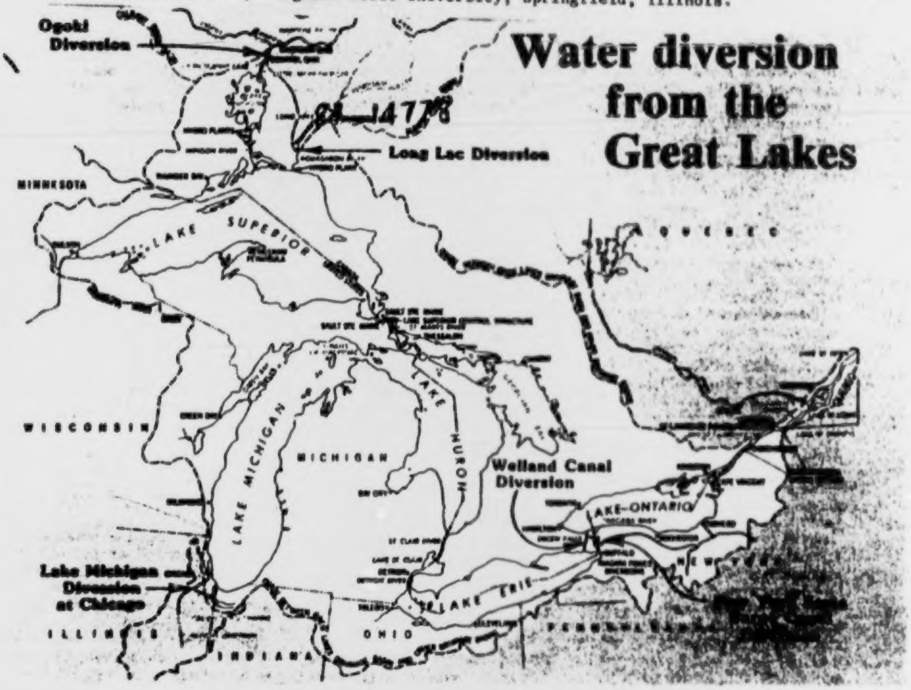
Water diversion from the Great Lakes



By KARL LEIF BATES

Among Illinois' chief resources is water. As an asset in economic development, abundant fresh water is key to this state and the region. This article explores a greater dimension of this resource — diversion of water from the Great Lakes — possibly beyond the states and Canadian provinces in the basin.

A HANDFUL of midwestern political groups and politicians — not to mention Canadians — are preparing to defend Great Lakes water from diversion to the West. At issue is protection of that abundant regional resource: water.

The 67 quadrillion gallons of water in the Great Lakes basin would, if spread evenly, cover the continental U.S. eight-feet deep. Ninety-five percent of North America's surface fresh water lies in the basin. Great Lakes defenders fear that they will eventually be asked to share this bounty. Their reluctance to do so, despite the enormity of the basin, stems from a long-standing reliance on this abundance of water close at hand.

Thirty-seven million Canadians and Americans now live in the Great Lakes basin and depend on its water for recreation, jobs and life itself. Twenty million people get their drinking water from the lakes, including Chicagoans and residents of Chicago's suburbs. Regional heavy industry and power generation also depend on the abundance of cool, fresh water in the lakes.

In 1975, an average of 75,600 cubic

feet per second (cfs) was withdrawn from the basin for these purposes. Of this, about 4,900 cfs (slightly less than what would fill one railroad boxcar) was not returned. This so-called "consumptive use" added up in 1975 to a total of 31 million freightcars full of water. At present, the U.S. accounts for about 88 percent of Great Lakes consumptive uses, against 12 percent by Canada. By 2035, a 1981 study by the International Joint Commission on the Great Lakes estimated, this ratio will change only slightly: 82 percent U.S., 18 percent Canada.

The 1981 study by the International Joint Commission estimated that consumptive uses of lake water by states and Canadian provinces in the basin would grow fivefold by 2035. A major cause of this increase will be modernized manufacturing and thermal power plants. These plants would base their cooling on evaporation, withdrawing less water than conventional facilities based on heat exchange for cooling, but consuming more. Growth in population and regional industry will also claim its share of consumption. Rainfall and runoff into the basin are not expected to expand accordingly.

What is expanding is a need for water in the western states. The West, despite its other attributes of sunshine, space and mineral resources, simply does not have enough water for its agricultural and urban development and may in the future have to look for help from distant sources, possibly as distant as the Great Lakes. The potential for plunder exists now, according to those who are organizing a defense. Being prepared well in advance of the actual threat of diversion is essential, they feel.

Water and farming

Agriculture, not cities, is the heaviest user of water, and agricultural growth in the western U.S. has come at the expense of finite aquifers like the Ogallala and rivers like the Colorado. A bushel of mature corn is said to contain a gallon of water, but 2,500 gallons of water are required to bring that bushel to maturity. Western and great plains agriculture is big business, and it has been using big water.

"They [westerners] have plenty of water to support another Los Angeles or lots of urban and industrial development," according to Charles Thurow, research director at the Center for the Great Lakes in Chicago. "The problem is agricultural development," he said.

Indeed, it seems to be only a matter of time before a Great Lakes diversion plan is proposed, according to some analysts. Agriculture in the high plains states of Kansas, Nebraska and parts of West Texas that has long depended on the huge Ogallala Aquifer is sucking the aquifer dry. Thousands of wells now sip constantly on the Ogallala to support farming where it was not previously possible. But the aquifer is falling 20 feet per year in some places. Most of the farmers in West Texas have given up spending the money to drill deeper and deeper to reach the water. They are reverting to "dry land" farming that relies only on natural precipitation and is not nearly as productive as irrigated farming.

Analysts estimate that acreage lost in Texas can be made up in Nebraska, where the Ogallala is more accessible, but even that option will become impractical in another 30 to 50 years, according to University of Michigan civil engineer Jonathan Bulkley.

"If I were in Nebraska, Kansas or Texas, I'd be looking seriously at the Great Lakes," said an environmental aide to Wisconsin Sen. Robert Kasten (R-Milwaukee). At present, the most likely threat to the Great Lakes would probably be efforts to recharge the southern, more shallow, part of the Ogallala, according to Tom Kuchenberg, a Washington-based author and consultant on the Great Lakes.

Although no plans have been drawn up to recharge the southern Ogallala, the Army Corps of Engineers has already worked out a preliminary plan for recharging the northern Ogallala from the Missouri River, drawing 10,000 cubic feet per second (cfs) out of the river at Ft. Randall, S.D., and St. Joseph, Mo. (Ten thousand cfs is roughly the volume of two railroad boxcars full of water leaving the river each second.)

To replace that water taken from the Missouri River, Bulkley and his colleagues have also worked out the preliminary engineering to take 10,000 cfs from massive Lake Superior, the headwaters of the Great Lakes chain, and move it to the Missouri River. It would be expensive, but it could be done. Their plan calls for canals to move Lake Superior's water roughly 600 miles from a spot near Duluth, Minn., to the Missouri River at Yankton, S.D. This would cost $19.6 billion, according to Bulkley's estimates. Eighteen pumping stations would be required to lift the water out of the Great Lakes basin to a spot where gravity would carry it through the canals toward the river. The power plants to run these 18 pumps would cost an estimated $7 billion. The annual operation of the whole system would add another $15 million per year. Total price: $26.6 billion to build, $15 million annually to operate. It would make for very expensive irrigation.

The Chicago River, flowing out of the lake, is like a drain in a bathtub. No other outlet has the potential of this one . . .

"I don't think that cost is that much of an obstacle in the long run," said Mike Donahue of the Great Lakes Commission. "Water is a necessity of life, and you are going to pay what you must for it." Lake defenders say they cannot expect cost to block diversion. "We don't know how important water will become. We could see a point when water becomes that valuable," said Donna Wise, president of The Center for the Great Lakes.

A 3,200 cfs diversion from the Great Lakes already exists at Chicago: Lake Michigan water is taken from three outlets and carried more than 300 miles to the Mississippi River via the Chicago and Illinois rivers. This diversion began nearly a century ago when the flow of the Chicago River was reversed to protect the fresh water of Lake Michigan, the source of Chicago's drinking water. The Chicago River, flowing out of the lake, is like a drain in a bathtub. No other outlet has the potential of this one to carry water outside the basin. At present, diversion of Lake Michigan water at Chicago is limited to 3,200 cfs; the limit was set by the U.S. Supreme Court in 1967.

A 1982 study by Bulkley and the Army Corps of Engineers determined that the Chicago diversion could be increased to 12,000 cfs for short periods without expanding the existing channels. During flood season, the rate would have to be lowered, but it would still average 8,700 cfs throughout the year according to the study's estimate.

Diverting another 10,000 cfs from Lake Michigan, however, would lower Lake Michigan-Huron by an estimated .67 feet. Lake Superior would fall less, .21 feet, because it is upstream. Lakes Erie and Ontario would fall .46 and .48 feet, respectively.

Engineers and economists can only guess at the damage that lowering the lakes would cause to the Great Lakes' environment, shipping and hydroelectric power generation. Some say that no price can be put on the damage to the shoreline ecology that a receding lake would cause.

As for shipping losses, cargo ships on the lakes are loaded to within inches of their maximum allowable draft, and lowering the lakes one inch can mean a 200-ton reduction in cargo capacity on some of the larger Great Lakes ships, many of which make up to 50 trips a year. Canadians estimate the cost to shipping of a one-inch drop at one million tons a year.

Less water going through the lakes also means less water to turn power-generating turbines, thus less cheap electricity for the region. The New York Power Authority estimates that its cost for switching to alternative fuels would be $10 million a year per 1,000 cfs diverted from the lakes. William G. Davis, premier of Ontario, has said that a six-inch drop in the lakes would cost his province $20 million annually in lost hydro-power.

If Great Lakes water must be diverted, the states and provinces in the basin would at least like to offset these losses. Wisconsin Gov. Lee Dreyfus suggested in 1982 that the Great Lakes states and provinces could become "an OPEC of fresh water" by controlling water in the basin and selling pieces of it to other regions at high prices.

The precedent for this would be a severance tax established by South Dakota in an agreement to sell Missouri River water to operators of a coal slurry pipeline project. Other states along the Missouri River sued, and the project is currently hung up in court. The severance tax question has yet to be resolved. At present, the Great Lakes region is far from any agreement on establishing such control over the lakes' water.

Water and the court

Nevertheless, recent court cases have opened up the Great Lakes basin's traditional legal protections, and groups and politicians who will defend the lakes have become concerned.

Great Lakes water levels have been protected since 1967 by a U.S. Supreme Court decision that, for economic reasons, limited the amount of water flowing out of Lake Michigan at the Chicago River. The court's reasoning, put simply, was that a lowering of the lakes creates economic losses to the region, and the court decided to control that effect by limiting the water diversion at Chicago.

A later court decision appears to limit states' control over water. In this 1982 decision, *Sporhase* v. *Nebraska*, the U.S. Supreme Court set a precedent. The court treated water as a "good" for interstate commerce and not as a resource. Under this decision, natural possession of the resource alone may not be an adequate reason to claim exclusive rights to its use. It seems unlikely that the water-rich states of the Great Lakes region can ban all diversions to dryer regions because such a ban could be seen as a barrier to interstate commerce.

Not everyone was concerned about the precedent set by *Sporhase*. The Illinois Department of Transportation (IDOT) issued a report that said in effect that *Sporhase* was not much to worry about. According to Daniel Injerd, chief of the Lake Michigan management section of IDOT and author of the report, these cases by themselves need not be an insurmountable obstacle to establishing control over the lakes. In his 1983 report to the Midwest Council of Great Lakes Governors, Injerd wrote that federal legislation could be passed to address the court's issues, and that intrabasin uses of water now and in the future may be sufficient to argue against any diversion outside the basin.

Suspense over the basin's defensibility has recently been heightened, however, by a federal district court decision, *El Paso* v. *Reynolds*, which is based on the *Sporhase* decision. El Paso, Texas, is using wells that draw drinking water from beneath New Mexico. New Mexico sued, claiming the water was its property, and lost in federal district court. The case is now under appeal.

This decision seems to indicate that "a state no longer has proprietary control over water," according to Kuchenberg, the consultant on the Great Lakes. "*El Paso* makes the point even more dramatically [than *Sporhase*]," he said. Kuchenberg calls this new doctrine of water rights as one of "use it or lose it": In other words, whoever can get to the water can use it. The Center for the Great Lakes is now undertaking a legal study of the *Sporhase* and *El Paso* decisions to see what they may mean for the Great Lakes basin.

Meanwhile, the lakes are protected by international treaty. The Boundary Waters Treaty of 1909 established the International Joint Commission (IJC), a Canadian-U.S. body responsible for studying and controlling lake levels and lake-related commerce throughout the basin. In theory at least, lake levels may not be altered without IJC permission.

The wild card in this hand, however, is Lake Michigan, which lies completely within the U.S. Lake watchers are divided on the question of whether Lake Michigan falls under the treaty's jurisdiction. Although the lake is entirely within the U.S., it is so closely linked with Lake Huron that IJC studies consider it one giant lake, Michigan-Huron. Extracting water from Lake Michigan cannot be done without also lowering the level of Lake Huron, which is bordered by both Canada and the U.S. (Lakes Erie and Ontario would also be affected, though to a lesser degree.)

The question of Lake Michigan's status under the Boundary Waters Treaty has yet to be answered, but the basin's defenders are not idly waiting for it to go to court.

Midwestern officials in Washington and in the region are organizing, lobbying and planning for the battle to defend the lakes. The Northeast-Midwest Coalition in Congress has taken up the cause, as have the Council of Great Lakes Governors and smaller groups like the Great Lakes Commission in Ann Arbor, Mich., and The Center for the Great Lakes.

Sen. Charles H. Percy of Illinois and other Great Lakes states congressmen have begun legislative efforts to protect the basin. Percy introduced Senate Bill 2026, which would have prohibited diversion without the permission of the IJC and the eight U.S. states and two Canadian provinces of the basin. In the flurry of activity at the close of this congressional session, however, S. 2026 was all but destroyed. All that remains of it, according to a Percy aide, is a clause that would prohibit any study of Great Lakes diversion. The aide noted, however, that prohibiting study is paramount to prohibiting action. Percy and Sen. David Durenburger (R-Minneapolis, Minn.) also amended a bill to prohibit inclusion of Great Lakes water in a study on recharging groundwater.

Congressmen from western states, although not directly proposing diversion of Great Lakes water, are reluctant to see any options eliminated by laws like these. Michigan, which is the only state entirely within the basin, also haggled over the water legislation: It wanted to ban all diversion to anyplace outside the basin.

Most analysts of the region agree, however, that a better boundary for limiting diversion from the basin would be a political one, based on state boundaries rather than on the basin itself. Regional unity and cooperation will be essential in establishing legislative barriers to diversion, and Michigan will probably be forced to compromise on these boundaries in order to establish any control at all over the lakes.

Time is very important — politically. "If the Great Lakes area is going to get its share of federal dollars and its active place in the nation, it's going to have to act quickly because we are losing population, and the balance in Congress is going more and more to the West," said Thurow of the Center for the Great Lakes.

Another strong defense might be the formation of a new regional compact. Pam Wiley, executive director of the Council of Great Lakes Governors, and Kuchenberg think that a compact is the best way to win the water battle. Organizing a compact may be difficult because of conflicting interests among the states. Illinois in particular is in a position to gain tax revenues from selling Lake Michigan water, and may want to retain that option. Illinois has never imposed a severance tax on its coal, partly because its high-sulfur content coal suffers in the market; Lake Michigan water should not have that drawback in any future freshwater market.

'It's not that we want to cut off water for [the West], it's just that we want to establish control'
— Sen. Percy aide

Although it may take nine years or more to organize a compact and get it approved by Congress, according to Mike Donahue of the Great Lakes Commission in Ann Arbor, this attempt to work together is worth it in the view of those who see diversion as a real threat. "For once, the region is looking at a long-term approach," said Donna Wise, president of The Center for the Great Lakes.

What appears to be a first step toward creating a compact is a charter being drafted for the Great Lakes states and provinces. It will be an amendable document that the governors and premiers could sign to set their bureaucracies in motion, according to Wiley. She explained that the charter would allow coordination among the states and provinces of conservation measures for the lakes and of control over their water. Wiley said in late October that the Great Lakes charter may be drafted in time for approval at a meeting in December.

Canada may very well be the trump card in this game. Four of the five Great Lakes have a Canadian shore. (Lake Michigan is the exception, but because it is so closely linked to Lake Huron, many feel that it too is included under the jurisdiction of the IJC in its role as protector of boundary waters.)

Canadians typically talk tough when the subject of a Great Lakes diversion comes up. Most analysts agree that Canada would lose the most if the lakes are lowered: Its most important manufacturing and urban centers are reliant on the lakes, as is much of its power generation.

"Diversion would be anathema to Canada," said Bruce Jutzi, who heads the environmental section of the Canadian Embassy in Washington. "The pressure that can be mounted to prevent it is substantial. The federal government of Canada would certainly be 100 percent behind the provinces," Jutzi said.

As for the Lake Michigan loophole in the Boundary Waters Treaty, "If Big Jim [Illinois Governor Thompson] wants to divert any water, he'd better have a good legal department," said Edward Hornby, an official of the Canadian consulate in Chicago. Both Hornby and Jutzi are confident that the Boundary Waters Treaty would be honored by the U.S. Supreme Court in any suit over diversion.

The international political division of the Great Lakes may act to preserve their sanctity in the long run, although Kuchenberg feels that balkanization is what got the lakes into trouble in the first place. "If the lakes were in any one country, they would be the centerpiece of that country," he said.

What the lakes will almost certainly become is the centerpiece of a heated national controversy. The court seems to have loosened the rights of resource ownership, opening the way for nationwide distribution of water. At the same time the states and provinces of the Great Lakes are determined to establish control of distribution and management of the water resources in the basin. "It's not that we want to cut off water for [the West], it's just that we want to establish control," explained Percy's aide.

Cooperation, unity, research and lead time are considered crucial to resolving the issue. Otherwise, the lakes may fall victim to the longstanding western doctrine of appropriation: If you can reach the water, you can use all you want.☐

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Saga of the Glades Continues

STEVE YATES

Steven Yates, formerly a seasonal hydrologist with the U.S. Forest Service, is an environmental writer and photographer whose work has appeared in Audubon *and* National Wildlife.

FLORIDA'S EVERGLADES have faced so many perils so often it seems like an old silent screen serial: miraculous rescues followed by impending disaster just as the curtain falls. In the last installment ("Marjory Stoneman Douglas and the Glades Crusade," *Audubon*, March 1983), we left the Glades clinging to the edge of a fateful abyss into which millions of creatures had recently vanished. The jaws of induced drought and unnatural flood gaped from below. Above, a small band of rescuers fended off menacing hoards of alien animals, exotic plants, indifferent politicians, and heavy machines. The saga continues, and the present episode may be the most absorbing one yet.

Just when it looked like curtains for the Glades, hope arrived in the unlikely form of the State of Florida, led by Governor Bob Graham. In August 1983, in his second gubernatorial term, he announced a stunningly comprehensive state program called Save Our Everglades.

To call this turn of plot ironic would be an understatement. For it was the State of Florida which had done its best for nearly 100 years to drain its 9,000 square miles of central and southern wetlands for sugar cane, cattle, and suburban sprawl. And in the late 1940s—up to its armpits no longer in alligators but in disastrous floods, soil loss, wildfire, and saltwater intrusion of drinking and irrigation water—it was the state which called in the Army Corps of Engineers. Congress responded with thirty years of federal appropriations to the Corps for a billion-dollar network of canals, levees, pumps, dams, locks, and flood-control structures. This enormous surface plumbing system was largely designed and operated by the state's South Florida Water Management District, formerly called the Central and Southern Florida Flood Control District.

The drainage and impoundments that resulted allowed cattle to roam the banks and former marshlands of the Kissimmee River, north of Lake Okeechobee; boats to cross the Florida peninsula through a diked Lake Okeechobee and its outlet canals; sugar cane to rule one of the world's greatest soil deposits south of the lake; suburbs and orchards to move into the eastern Everglades. In addition, a huge jetport surrounded by a new city half the size of Miami was proposed for Big Cypress Swamp, west of the Everglades; rich Everglades peat was (and is) mined as sod for suburban lawns; subdivisions were platted underwater with the expectation of further drainage.

But unforeseen side effects rudely intruded. Within a single generation, 90 percent of Everglades National Park's nesting wading birds had vanished, along with 90 percent of the Kissimmee Basin's waterfowl. The stagnant oxbows of the Kissimmee River and the increasingly salty waters of Florida Bay lost their allure to fishermen. Snook, a prized game fish, disappeared. The Biscayne Aquifer, primary source of drinking water for south Florida's four million people, was threatened by saltwater intrusion, while Lake Okeechobee, its backup water source, turned eutrophic from fertilizer wastes. Events in the spring and summer of 1982 dramatically highlighted the system's failings.

In February of that year, following two years of drought, torrential rains flooded the shallow Kissimmee Basin. Canal C-38, the 50-mile-long, 150- to 300-foot-wide "Kissimmee Ditch," worked as designed, draining the basin's waters southward eleven times faster than the meandering Kissimmee River once had. The shunted water helped fill Lake Okeechobee to record heights. Bound by specific regulations, the Corps then opened the floodgates to prevent storm-driven waves from breaching the surrounding dikes. A massive slug of freshwater, laden with silt, surged out the St. Lucie Canal to the Atlantic to devastate the St. Lucie estuary.

Since most of the outlet canals were themselves full, water was also shunted south into the water conservation area impoundments. The largest impoundment, just north of Everglades National Park, filled to capacity, inundating the feeding grounds of the large deer herd that had built up during the previous dry years. Faced with starving deer, the Florida Game and Fresh Water Fish Commission ordered an emergency deer hunt that summer, a hunt so controversial that it made the national evening news for weeks.

The Corps, again bound by regulations, then opened the conservation area floodgates into Everglades National

Park, drowning alligator nests and preventing wood storks and other wading birds from nesting. Only the park's estuaries on Florida Bay and the Gulf of Mexico, thirsty for decades from upstream impoundments, seemed to be helped. In all other respects, it was an environmental disaster and public relations fiasco.

Governor Bob Graham, whose environmental record as state legislator and as governor had been unusually strong, immediately appointed a blue-ribbon Everglades Wildlife Management Committee, chaired by state environmental planner Estus Whitfield, to recommend ways to better manage the deer herds and to save the endangered Florida panther. Graham consulted with author and conservationist Marjory Stoneman Douglas, historian and water specialist Norman Blake, regional planner Earl Starns, and experts from the national park, the state's South Florida Water Management District, Game and Fresh Water Fish Commission, and Departments of Environmental Regulation and Natural Resources. Save Our Everglades was the result.

Save Our Everglades is a logical successor to Graham's Save Our Rivers and Save Our Coasts programs, and while much of it simply patches together previous ideas, its overall thrust is comprehensive and sophisticated. It is designed "to provide that by the year 2000 the Everglades will look and function more as it did in 1900 than it does today."

The program's main goals are: (1) to restore the Kissimmee Basin; (2) to restore state lands north of the water conservation areas; (3) to manage the Everglades deer herd at a size consistent with maximum flood levels; (4) to improve Alligator Alley and the Tamiami Trail (the two main roads crossing Big Cypress and the Everglades), so that they no longer impede the southward flow of surface water; (5) to restore Everglades National Park (including acquisition and restoration of the East Everglades portions of Shark River and Taylor sloughs); and (6) to preserve the Florida panther, only twenty to thirty of which now survive.

SO FAR Save Our Everglades has moved with amazing speed. Graham has reconstructed the board of the powerful South Florida Water Management District with new appointments to five vacancies, including that of longtime chairman Robert Clark. Executive director Jack Maloy, an unreconstructed proponent of the original flood-control and drainage dream, also resigned and was replaced by his former assistant, John Wodraska. New appointees to the Water Management District board include three people who have excellent environmental records and were strongly endorsed by Audubon societies in Florida. Remaining on the board is Nathaniel P. Reed, who is chairman of National Audubon Society's executive committee.

The five state water management districts have become even more powerful since the recent passage of the state's wetlands bill, which transfers regulation of agriculture within the districts from the Department of Environmental Regulation to the districts themselves. By defining the boundaries of the Everglades, the wetlands bill clarifies the ability of the districts and the Department of Environmental Regulation to regulate activities on the biologically critical edges of the Glades. The new Water Management District board lost no time in turning down two applications for permits to drain wetlands for proposed farming operations.

The state's ambitious goals are complicated by the lead role of the Corps of Engineers in operating the federally funded plumbing system that controls water movement throughout southern Florida. According to Save Our Everglades program coordinator Estus Whitfield of the governor's office, the Corps' Jacksonville office has been "extremely cooperative." But plugging canals, digging holes in dikes, and reflooding wetlands are new and unsettling tasks for the Corps. Congressional authorizations, rigid flood-control regulations, and huge investments of past work and money are involved.

In one of Save Our Everglades' first steps, the South Florida Water Management District received a Corps permit to divert part of the Kissimmee Ditch's flow back into the Kissimmee River, a top priority of state conservationists. Even at its present "demonstration" scale, the project is historic. It is the first time that a large federal water project has been reversed in its intent.

On July 26, 1984, almost a year from the day the Save Our Everglades program was announced, Governor Graham and Marjory Stoneman Douglas stood side by side at the dedication ceremony of the Kissimmee River restoration project. A few days later, the South Florida Water Management District began installing the first of three steel weirs to divert some of the ditch's flow back into sixteen miles of the old river channel. Eventually, if Congress will authorize it, more of the river will be filled with water and allowed to overflow during the rainy season.

The district plans to spend up to $65 million ($36 million more than it cost to dig the ditch in the first place) to regain the benefits of seasonally flooded marshes in the flat, shallow basin. But the benefits will be even greater: enhanced water storage during drought and slower release during flood; purification of water by the restored marshes, prime river and marsh habitat for fish, crayfish, alligators, waterfowl, wading birds, eagles, and ospreys; fewer massive discharges through Lake Okeechobee to the coastal estuaries and Everglades National Park.

The Corps of Engineers expects to send a draft of its recommendations for the future of the Kissimmee to the state for review before this goes to press. Eventually, Florida's congressional delegation must introduce a bill to authorize further actions.

"The Kissimmee is going to be the most difficult part of the Save Our Everglades program," Estus Whitfield says. "Nothing like this has ever been done. There are property owners and interests which don't want restoration; some could take political and legal actions against it. It's going to take a lot of push to get this one done. But if we can do it, everything else should be relatively easy."

Northwest of Everglades National Park, in the area of Big Cypress National Preserve and the state's Fakahatchee Strand, things have moved swiftly. The Big Cypress jetport proposal, still kicking feebly after fifteen years, was finally laid to rest. Collier Enterprises has agreed to place fifty square miles of wetlands into a ten-year "conservation trust" and to sell to the state whatever lands are needed for the Big Cypress part of the Save Our Everglades program.

At the same time, the U.S. Fish and Wildlife Service has proposed a new national wildlife refuge in the northern quarter of the Fakahatchee Strand, a large hardwood swamp along the western edge of the Big Cypress National Preserve. The strand, part of which is already a state preserve, contains the greatest diversity of plants and animals in the Big Cypress area and the greatest density of Florida panthers. In conjunction with the upgrading of Alligator Alley to interstate-highway status, the state plans to buy another 200 square miles of land north of the Big Cypress, hoping that it will ultimately be added to the preserve.

Redesign of the east–west Alligator Alley interstate (I-75) should greatly improve the flow of surface water beneath it. It will also allow safe passage under the road for the endangered panther, whose main cause of mortality is crossing Alligator Alley and a state road nearby.

EAST OF EVERGLADES National Park another important part of the restoration effort is taking place. The Water Management District and the Department of Natural Resources have bought ninety square miles of land critical to park water supplies in the East Everglades and are negotiating for more. In 1983 Congressman Dante Fascell successfully introduced a bill authorizing first steps toward restoring water flow through northeast Shark River Slough into the park. The bill directs the Corps to study the effects of a more natural water regime and to recommend flood-control measures to protect the farming and residential areas now established on the eastern edge of the floodplain. As a demonstration project, the Corps is allowing a limited amount of water to flow eastward into northeast Shark River Slough and thence southward into the park.

Governor Graham has appointed an Everglades National Park–East Everglades Resource Management Committee to work out some of the sticky issues involved. Neither the Corps nor the Water Management District is a land management agency; the National Park Service, the obvious choice to manage this critically important water source adjacent to Everglades National Park, has not been buying land of late.

The national park last year submitted a seven-point plan to the Corps to bring about a more natural water delivery system. The Corps immediately plugged sections of two canals and opened gates in other canals to reconnect the park's water flow from Big Cypress and East Everglades. According to park hydrologists, these measures, and the spreading of some water into northeast Shark River Slough, may be too tentative to be really effective; but they are heartening beginnings.

Another major improvement would be to plug the infamous Aerojet Canal (C-111) that skirts the park's southeastern boundary. The canal was originally dug as a federal- and state-financed waterway to barge huge moon-rocket engines from a proposed Aerojet General factory on the edge of the park to the Atlantic Ocean and thence up to Cape Canaveral. The rocket-engine scheme never got off the ground, but the controversial canal has continued to drain water from the park's Taylor Slough and to deprive Florida Bay's eastern estuaries of desperately needed freshwater. Fishermen have blamed the canal for ruining fishing in the eastern bay, last home of the endangered American crocodile. The canal has been partly plugged to push some water back into the park; its ultimate fate is being studied by the state and the Corps.

In order to more closely approximate natural conditions, the Corps—at the park's request—has left open the gates through which water flows south into Shark River Slough. The park hopes that before closing the gates again the South Florida Water Management District will have to justify the amount of drought-protection water it feels necessary to store in the water conservation area north of the park. Previously, all water above and beyond the congressionally mandated minimum releases to the park was impounded until reaching flood levels, at which time it was dumped into the park, often with devastating results.

The park, the Corps, and the Water Management District are still working on an improved schedule of water release for the park. The Corps has hired respected aquatic biologist Durbin Tabb to make water-schedule recommendations; the National Park Service hopes these will agree with those suggested by its South Florida Research Center.

If all of the Save Our Everglades measures are successful, Everglades National Park might well "look and function more as it did in 1900 than it does today." If these efforts fail, the probable long-term alternative is that our last subtropical wilderness will look like a huge field of exotic weeds and function not at all. "There is no question," says National Audubon's Florida representative Larry Thompson, "the fate of Everglades National Park hangs in the balance."

Thompson is putting his energies into forming a coalition of groups involved in saving the Everglades. Now that there is a well-defined state program, it may be easier than in the past for the scattered groups—often divided by uncompromising leaders, territorial battles, and historic feuds—to define common goals and strategies.

So far, Save Our Everglades has drawn rave reviews for its first year's efforts and guarded optimism about its future. Even the Corps, though it moves more slowly and cautiously than many would like, is getting a share of grudging praise from its usual critics. The next rounds will be fought at the national level. If the Corps study reports are favorable, and if Florida's congressional delegation is cooperative, south Florida's water management system may yet be modified to benefit the entire Kissimmee/Lake Okeechobee/Everglades ecosystem.

Estus Whitfield, who describes himself as "low-key and not easily excited" and who has been in state government long enough to be skeptical of almost all government programs, is even more enthused by Save Our Everglades now than when it was first announced: "I think the momentum behind what's going on will carry through into other administrations. Hopefully, public support will be even greater then. We need to have this program well established and under way to the extent that it would be imprudent, uneconomical, and illogical not to continue it. Save Our Everglades is the most exciting thing I've ever been associated with professionally. I just hope that we can keep it moving forward."

Given Governor Graham's unwavering commitment to the program, our richest and most complex aquatic ecosystem may yet be pulled from the edge of the abyss. If Audubon members give full support when Save Our Everglades initiatives reach Congress, some future episode of "The Perils of the Everglades" just might be titled "Wetlands Paradise Regained." ♠

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In this article the author examines the United States Supreme Court's recent decision in Sporhase v. Nebraska. He discusses the implications the decision has for western states' attempts to control their water resources and suggests a revision in the Court's approach to such questions.

SO ITS NOT "OURS" - WHY CAN'T WE STILL KEEP IT? A FIRST LOOK AT SPORHASE V. NEBRASKA

By
*A. Dan Tarlock**

INTRODUCTION: THE ORIGINS OF WESTERN CLAIMS OF RESOURCE SOVEREIGNTY

With one exception, God was good to the West. He gave it great natural beauty (accentuated by some vast, barren stretches), abundant and varied natural resources, and substantial areas of productive soil. However, he failed to provide enough water to enjoy and exploit these gifts with abandon. An Old Testament explanation for the perversity of western geography might conclude that God did this to test man's ability to use the gifts wisely. Certainly, many of those who originally went West did so in the Old Testament spirit of settling a promised land to exploit it. From the middle of the nineteenth to the early twentieth centuries, the West was settled as a society based on mining, livestock grazing, and irrigated agriculture.[1]

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[1] The origins of western settlement are traced in R.A. BILLINGTON, THE FAR WESTERN FRONTIER: 1830-1860 (1956).

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One had to be hardy to survive outside of the more gentle Pacific Coast region, and those who did took justifiable pride in this accomplishment and naturally thought that they had earned the exclusive right to chart the region's future.[2] They therefore resented sharing control of their resources with other parts of the country. But, however justified this labor theory of exclusive sovereignty was, it was made by colonists. The West was, until very recently, a resource rich, capital poor region.[3] Eastern and foreign capital was necessary to develop the resources, and the western states were subject to a national government that claimed not only superior political sovereignty but also, as proprietor of the public domain, proprietary ownership of much of the West's wealth.

Still, the West had reason to expect that it would gain exclusive sovereignty over the key to its destiny, its natural resources. The federal government failed to assert its claims to the mineral and water wealth on the public domain until much of that wealth had passed into private hands.[4] Furthermore, for much of the nineteenth century it appeared that the federal government would dispose of most of the public domain to the states and to private parties.[5] However, the disposition era of the public domain ended before the West was fully settled and disposed of so the federal government ended up owning vast areas of public land or severed mineral titles. This and the distance between Washington and the West have made the region feel threatened by the national government and somewhat disdainful of its expertise and direction.

Although the West never fully adjusted to the shifts in public lands policy from disposition to simultaneous retention and disposition and ultimately to retention and comprehensive management, as the latest Sagebrush Rebellion illustrates,[6] it has been able to live with less than full resource sovereignty. There has been of course, and always will be, conflict — at times substantial conflict[7] — between federal and state resource policies, but an overall congruence of interest in areas such as grazing, mineral leasing, timber production and reclamation has kept the friction tolerable. The shock of shared control was further softened because the states did effectively retain exclusive control over the one resource, water, that determined the growth of the region. The doctrine of prior appropriation, upon which western water law is based, helped to contain sectional conflicts because it served both federal and state interests well. Appropriation supported an irrigation and livestock economy desired by both governments and gave mineral and other industries adequate access to water.[8]

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[2] *See* R. ATHEARN, HIGH COUNTRY EMPIRE 207 (1960).

[3] The history of the west's transition from a colony to a major region of the United States is described in G. NASH, THE AMERICAN WEST IN THE TWENTIETH CENTURY: A SHORT HISTORY OF AN URBAN OASIS (1973).

[4] For example, coal lands were withdrawn in 1905 and 1906 after "[i]t had been discovered by the Geological Survey that large areas of valuable coal lands in the West had been obtained from the government by means of agricultural entries." B. HIBBARD, A HISTORY OF THE PUBLIC LAND POLICIES 518 (1924 U. Wis. ed. 1965).

[5] GATES, A HISTORY OF PUBLIC LAND LAW (1968) is the standard history of public domain policy.

Western adjustment to shared resource sovereignty was made possible by a long period of gradual growth after the initial rush of settlement. But, in the 1970's, the West began to come into its own as its population grew rapidly. People were drawn to the region by the somewhat incompatible lures of amenity and energy.

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[6] The Western states have always felt cheated that the disposition era ended before they or private patentees obtained title to the public domain. In recent years, the Western states, having failed to convince Congress to cede either control or ownership of the bulk of the public lands to the states, have asserted ownership of large amounts of the public lands under various legal theories. Those theories conclude that the federal government has a constitutional duty to divest itself of non-wilderness national forest lands, and lands managed by the Bureau of Land Management under the Taylor Grazing Act. The strongest constitutional argument asserted by the states is that the equal footing doctrine, as interpreted in Pollard v. Hagen, 15 U.S. (3 How.) 391 (1844), imposes a duty on the federal government to put new states on a resource par with the original 13 states (the federal government has no retained lands in the original states). To date, this argument has been properly rejected. Nevada State Bd. of Agriculture v. United States, 512 F. Supp. 166 (D. Nev. 1981).

For an overview of the history of earlier divestiture movements, see L. Peffer, The Closing of the Public Domain (1951). For a review of current legal arguments, see Leshy, *Unravelling the Sagebrush Rebellion: Law, Politics and Federal Lands*, 14 U.C.D. L. Rev. 317 (1980); Mollison and Eddy, Jr., *The Sagebrush Rebellion: A Simplistic Response to the Complex Problems of Federal Land Manogement*, 19 Harv. J. on Legis. 97 (1982); Note, *The Property Power, Federalism, and the Equal Footing Doctrine*, 80 Colum. L. Rev. 817 (1980) and Note, *The Sagebrush Rebellion: Who Should Control the Public Lands?* 1980 Utah L. Rev. 505.

[7] For a review of the classic twentieth century public lands battles, see L. Peffer, *supra* note 6, and *Regional Conflict and National Policy*, 70 Resources 1, July, 1982.

[8] The vision of Wyoming's irrigation economy in 1940 is described in Wyoming: A Guide to its History, Highways, and People 105-08 (1941). *See also* Trelease, *The Role of Water Law in Conserving and Developing Natural Resources in the West*, 18 Wyo. L.J. 3 (1963).

The energy boom in states such as Wyoming has stressed both the states' resources[9] and their institutions, including the traditional assumption of the law of prior appropriation that the locus of use is irrelevant to the right. Most western states have reacted with both concern and gratitude to the energy boom because it threatens to change substantially or destroy the uniqueness of the region in return for instant prosperity. Nowhere is this dual view of energy development better reflected than in state policies on the use of water for coal slurry pipelines.[10]

Wyoming, along with other states, has singled out the use of water for coal slurry pipelines for special regulation and has placed severe restrictions on water use for interstate pipelines. These statutes may represent yet another chapter in the endless friction between state and national interests. As a matter of federal constitutional law, it is said that export barriers may violate the negative commerce clause,[11] and as a matter of legislative policy, it is said that they may be inconsistent with the national goal of energy independence.[12]

In the 1981-82 Term, the Supreme Court held that water was an article of interstate commerce, despite the strenuous, longstanding arguments of the western states that state ownership in trust for the public immunized state water law from negative commerce clause review. In *Sporhase v. Nebraska,*[13] the Court found that a Nebraska statute prohibiting the export of water from the state violated the negative commerce clause.

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[9] *See* Doherty, *Wyoming Plays Its Hole Card*, SPORTS ILLUSTRATED, May 17, 1982, at 75.

[10] *See generally* C. BORIS & J. KRUTILLA, WATER RIGHTS AND ENERGY DEVELOPMENT IN THE YELLOWSTONE RIVER BASIN (1980); ACQUIRING WATER FOR ENERGY: INSTITUTIONAL ASPECTS (G. Weatherford ed. 1982).

[11] Tarlock, *Western Water Law and Coal Development*, 51 U. COLO. L. REV. 511, 538-41 (1980); Martz and Grazis, *Interstate Transfers of Water and Water Rights — The Slurry Issue*, 23 ROCKY MTN. MIN. L. INST. 33 (1977); Corker, *Can a State Embargo the Export of Water by Transbasin Diversion?* 12 IDAHO L. REV. 135 (1976); Comment, *Do State Water Anti-Exploration Statutes Violate the Commerce Clause, or Will New Mexico's Embargo Statute Hold Water?* 21 NAT. RESOURCES J. 617 (1981); Comment, *"It's Our Water" — Can Wyoming Constitutionally Prohibit the Exportation of State Waters?* 10 LAND & WATER L. REV. 119 (1975).

[12] Clyde, *State Prohibitions on Interstate Exportation of Scarce Water Resources*, 53 U. COLO. L. REV. 529, 531 (1982).

Sporhase will be hailed by many as the death knell for all state export ban statutes, including Wyoming's coal slurry legislation, but this may be a premature conclusion. This article attempts to develop, within the framework of the *Sporhase* analysis, an approach to export statutes that allows a state to assert its essential interests in determining the locus of water use. This effort is animated by the normative argument that there is no basis for federal preemption of state water law in this or any other energy issue.[14]

A. The Coal Slurry Problem: Resource Sovereignty Aroused

After the Arab Oil Embargo of 1973, the federal government announced a goal of energy independence. Under Presidents Ford and Carter this goal was to be implemented, in part, by increasing the use of abundant domestic resources. After a long period of neglect and shrinking markets, coal was again nominated for energy stardom.[15]

One goal of the new coal policy was to transport coal as cheaply as possible from areas of supply to areas of demand. Pipeline companies argued that this could be done, by changing lump coal into slurry and piping the mixture to areas of high demand, such as the Southeast.[16] Railroads, afraid of losing a near monopoly on western coal transportation, objected strenuously to such proposals. Western ranchers and environmentalists objected as well, fearing the impact on water resources. Estimates vary, but the amounts involved are substantial.[17]

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[13] ___ U.S. ___, 102 S.Ct. 3456 (1982).

[14] *See* Tarlock and Fairfax, *Federal Proprietary [Water] Rights for Western Energy Development: An Analysis of Red Herring?* 3 J. ENERGY L. & POL'Y 1 (1982).

[15] *See* Tarlock, *Western Coal in Context,* 53 U. COLO. L. REV. 315 (1982) (This article provides a brief history of the role of coal in Post-World War II energy planning).

[16] For an early summary of the pipeline companies' arguments, see Haerle, *Legal and Practical Aspects of Coal Slurry Construction and Use,* in COAL CONVERSION: PRACTICAL AND LEGAL IMPLICATIONS 217 (P.L.I. 1977).

The issue took on an added edge, which has now blurred, during the mid-1970's when the West was awash with energy and water studies that forecast the drying up of western streams to develop conventional and unconventional energy sources and to generate electricity to keep pace with demand. Western states responded to these vague fears of water depletion with a variety of export ban statutes, many of which singled out coal slurry pipelines either directly or indirectly. The issue became complicated when the pipelines turned to Congress for national legislation giving them the power of eminent domain in order to circumvent the railroads' refusal to grant rights of way under their tracks. The water issue quickly became enmeshed in the pipeline legislation, which has yet to pass Congress.[18]

B. Water Export Bans: Resource Sovereignty Asserted

Western states have enacted a variety of laws to limit the diversion of water for out-of-state uses. A few states have flat export prohibitions. New Mexico flatly prohibits the withdrawal of all groundwater for out-of-state uses.[19] Montana prohibits the export of all waters and, to be doubly safe, provides that the use of water for coal slurry is nonbeneficial.[20] Similar legislation exists in Oklahoma.[21] Prohibitions in other states are facially less absolute but have the effect of barring out-of-state uses. Nebraska,[22] Nevada[23] and Washington[24] limit out-of-state diversions to states that allow a reciprocal right of interstate use. Colorado also has a reciprocity statute, but in addition to demonstrating host-state reciprocity, the diverter must obtain legislative approval for an out-of-state use.[25]

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[17] *See* Office of Technology Assessment, The Direct Use of Coal 237 (1979); Boris & Krutilla, *supra* note 10, at 123-25.

[18] *See* Comment, *Do State Restrictions on Water Use by Slurry Pipelines Violate the Commerce Clause?* 53 U. Colo. L. Rev. 655 (1982).

[19] The prohibition extends to drilling a well on New Mexico territory and transporting the water out of state or by drilling on the territory of a neighboring state and extracting the water from beneath land lying within New Mexico's boundaries. However, the statute expressly allows the out-of-state transportation by tank truck of water withdrawn from an underground source if the water will be used out of state for exploration and drilling for oil and gas. The maximum allowable amount of water withdrawn from any one well for exploration may not exceed three acre-feet. The statute also prescribes certain duties owed by the owner of a well from which water for export is withdrawn. He must ascertain that the water is exported only for use in oil and gas drilling. He must also keep records of the amount of water withdrawn for export. These records are subject to state inspection. N.M. Stat. Ann. § 72-12-19 (1978).

[20] An act of the legislature would be required in Montana to circumvent the flat prohibition laid down by the statute: "None of the waters in the state of Montana shall ever be appropriated, diverted, impounded or otherwise restrained or controlled while within the state for use outside the boundaries thereof, . . ." Mont. Code Ann. § 85-1-121 (1981). Mont. Code Ann.

Concern over the use of water has led other states to the requirement of legislative approval for any out-of-state uses. Wyoming has required that slurry coal pipelines receive legislative approval.[26] South Dakota requires legisla-

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§ 85-2-104(1) and (2) (1981) provides that using water "for the slurry transport of coal is detrimental to the conservation and protection of the water resources of the state" and that such use "is not a beneficial use of water." For a useful discussion of the legislative history of the Montana legislation, see Comment, *Coal Slurry: All Quiet On the Western Front?* 3 THE PUB. LAND L. REV. 156 (1982).

[21] "No Oklahoma water from any source shall be used in connection with the transportation, maintenance or operation of a coal slurry pipeline within or through the State of Oklahoma." OKLA. STAT. ANN. tit. 27, § 7.6 (West Supp. 1977).

[22] Nebraska requires that anyone intending to divert water for an out-of-state use must file a permit application with the Department of Water Resources. The permit will be granted if the Director finds that the request "is reasonable, is not contrary to the conservation and use of groundwater, and is not otherwise detrimental to the public welfare." NEB. REV. STAT. § 46.613.01 (Reissue 1978). This statute was held unconstitutional in Sporhase v. Nebraska, U.S. .., 102 S.Ct. 3456 (1982).

[23] NEV. REV. STAT. § 533.515 (1979).

[24] The Washington statute differs from those of Nebraska and Nevada in that the granting of permits for diversion of Washington water to another state is discretionary with the Supervisor of Water Resources, unless the other state has enacted a reciprocity statute. WASH. REV. CODE ANN. § 90.03.300 (1962). On the statute's face the Supervisor may allow appropriation of water to a state that does *not* have a reciprocity statute. However, the last section of the Water Rights Act specifies that the provisions of the Water Rights Act shall not apply to any state which does not grant reciprocal rights to the state of Washington. WASH. REV. CODE ANN. § 90.16.120 (1962).

[25] COLO. REV. STAT. § 37-81-101 (Supp. 1981). Colorado prohibits, in most instances, diversion of its waters outside its boundaries. However, the use of Colorado water outside the state is allowed only where an owner of agricultural land within Colorado also owns agricultural land in another state, and the Colorado water is to be used only for agricultural purposes. The statute requires that the land in Colorado be contiguous with the land in the adjacent state. In addition, legislative approval (on the advice of the state engineer) is required for such use. A factor in the legislature's decision will be the "willingness of said state to allow diversions of its water for use in Colorado." COLO. REV. STAT. § 37-81-101 (Supp. 1982).

[26] WYO. STAT. § 41-3-105 (1977). The Wyoming statute allows an interstate appropriation of water only to states that have granted reciprocal rights. WYO. STAT. § 41-3-115(c) (1977). In addition, the use of Wyoming water as a means of transportation of mineral or chemical products outside the state without prior legislative approval is prohibited. WYO. STAT. § 41-3-115(b) (1977). These provisions do not extend to the use of Wyoming water in coal slurry pipelines. Generally, however, *any* use of water outside the state must be with the prior consent of the legislature. WYO. STAT.

tive approval for all diversions over ten thousand acre-feet annually, except "for the approval of water permits for energy industry use."[27] The export of water for coal slurry pipelines is controlled by other statutes that are not designed to conserve water for in-state use, but to allow the state to enter the water market directly. Oregon requires that all interstate diversions obtain legislative consent.[28]

In general, there is very little positive to be said for water export barriers. Such statutes frustrate the efficient allocation of water resources because they prevent the market from operating to shift uses to the areas of the highest demand. Economic efficiency is, by general consensus, the major goal of water resources allocation. Of course, the state has plenary power to choose goals other than efficiency.[29] Ideally, however, when allocative efficiency is subordinated to equity, one ought to be able to identify with some precision the alternative goals sought to be advanced by the legislation. Judged by this standard, the statutes by and large fail.

It is easy to imagine state interests that might be served by export barriers. However, the statutes, like so much of mega-water law and water politics, are poses. They reflect a variety of fears about what might happen if

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§ 41-3-105 (1977). Wyoming has special provisions which legislatively approve the Energy Transportation Systems' (ETSI) coal slurry pipeline proposal. The statute provides a two-tiered screening procedure for this coal slurry pipeline use application. The application must first be approved by the state engineer and then by the legislature. Furthermore, diversions are limited to twenty thousand acre-feet annually. WYO. STAT. § 41-3-115(d) (1977). The Wyoming legislature grandfathered ETSI's pipeline application statute subject to stringent conditions to protect vested rights. WYO. STAT. § 41-3-115(g) (Supp. 1982).

[27] Under the South Dakota statute, the Water Management Board must present any application for appropriation of over ten thousand acre-feet of water to the legislature for approval. However, even if the legislature approves the application, the Water Management Board has the final word. The statute states expressly that legislative approval does not constitute an issuance of a water permit. S.D. COMP. LAWS ANN. § 46.5.20.1 (Supp. 1982). See *infra* note 105 for a further discussion of South Dakota's water allocation scheme.

[28] Oregon law requires legislative approval of an out-of-state diversion of Oregon water. The statute gives the legislature the discretion to attach to an application any "terms, conditions, exception, reservations, restrictions and provisions as it may care to make in the protection of the interests of the state and its inhabitants." OR. REV. STAT. § 537.810 (1981).

[29] *See* Trelease, *Policies for Water Law: Property Rights, Economic Forces, and Public Regulation*, 5 NAT. RESOURCES J. 1 (1965).

"outsiders" gained access to "our" water.[30] There is little evidence that they are necessary to conserve essential supplies on which the state's population depends. Nor is there much evidence that the statutes represent a reservation of future supplies to prevent future shortages and to allow various intrastate development plans to be realized. These statutes bear only a superficial resemblance to more careful area protection schemes such as California's area of origin statutes[31] or Nebraska's recent effort to condition transbasin diversions.[32]

C. Limits on Exclusive State Control Over Water: The Duty to Share

By law, tradition, and history, western states possess a strong expectation that they may control the allocation of waters arising within their borders. But, however strong the expectation of exclusive control, state claims are subject to two interstate, and one inter-sovereign, sharing duties. Common property claimants have equal claims; thus, the law has always recognized that common resources such as interstate streams must be shared among riparian states. The Supreme Court's power to decree equitable apportionments means that "higherority" can never be a perfect priority.[33] States are quasi-sovereign units of a federal system, and the national government can require that state interests be subordinated to federal interests. This subordination is accomplished under the authority of the commerce and supremacy clauses. Congress has plenary power to allocate navigable waters among states under the commerce and other clauses, and courts may use the negative commerce clause to do this. In addition to the two extraterritorial sharing duties, western states must share some, although not a great deal, of their waters with the federal government. The federal government's proprietary ownership of the public lands entitles Congress to claim reserved water rights when public lands (and Indian reservations) are dedicated to a water-related use.[34]

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[30] Clyde, *supra* note 12, at 530-31.

[31] Robie and Kletzing, *Area of Origin Statutes — The California Experience*, 15 IDAHO L. REV. 419 (1979).

[32] NEB. REV. STAT. § 46-265 was amended in 1981, 1981 NEB. LAWS 252, in response to *Little Blue N. Natural Resources Dist. v. Lower Platte Natural Resources Dist.*, 206 Neb. 535, 294 N.W.2d 598 (1980), which overruled a prior Nebraska case prohibiting transbasin diversions. *See also* Little Blue N. Natural Resources Dist. v. Lower Platte Natural Resources Dist., 201 Neb. 862, 317 N.W.2d 726 (1982).

[33] *See* Wyoming v. Colorado, 259 U.S. 419 (1922).

The commerce clause is both a grant of legislative power to Congress and a judicially administered restraint on state legislation alleged to be inconsistent with federal interests. At one time, the scope of Congress' power over waters not navigable under historic tests was unclear. This is no longer the case, but the use of the negative commerce clause continues to be controversial. The negative commerce clause is important to the West because it threatens to nullify state efforts to block the diversion of intrastate waters for out-of-state uses. A long line of Supreme Court cases has progressively undermined state claims to exclusive rights to allocate their waters free from negative commerce clause review. In the 1981-82 Term, the Court decided *Sporhase v. Nebraska*, which held that a state law prohibiting the transportation of water diverted in Nebraska out of state unless the host state permitted reciprocal interstate diversions, violated the negative commerce clause.

Chief Justice Marshall first announced the negative commerce clause doctrine in *Gibbons v. Ogden* in 1824,[35] but the legitimacy of the use of the doctrine is questioned as much today as it was by early critics. The doctrine lacks textual support in the Constitution, and the results of recent Supreme Court opinions suggest that the Court is ill-suited to play the grand role of regional conflict adjuster.

Both Marshall and subsequent promoters of the doctrine have sought to validate the doctrine by the theory that the benefits of federal union are constantly being undermined by parochial state legislation. Building on Mr. Justice Jackson's opinion in *H.P. Hood & Sons, Inc. v. DuMond,*[36] Professor Ernest Brown articulated the current justification for the active use of the doctrine to scrutinize state legislation said to have an adverse impact on interstate commerce: it is appropriate for the Court to reinforce the nationalist vision of free trade among the states in situations where state legislatures have enacted anti-competitive statutes that are unlikely to be the subject of Congressional review and revision.[37]

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[34] Cappaert v. United States, 426 U.S. 128 (1976). As a result of United States v. New Mexico, 438 U.S. 696 (1978), the federal government must meet a strict three-part test. The right must relate to the original purpose of the reservation, the right must be necessary to prevent the frustration of the primary purpose of the reservation and the right must be for a primary, not secondary, purpose of the reservation. For a discussion of the federal reserved rights doctrine, and a summary of the voluminous literature that has developed around it, see Tarlock and Fairfax, *supra* note 14.

[35] 6 U.S. (9 Wheat.) 1 (1824).

Given a federal system that allows states considerable discretion to adopt regulatory schemes, especially those that further traditional spheres of state interest, but that must of necessity effect interstate commerce, it is not easy to articulate what should be the Supreme Court's role in deciding if a piece of legislation or a regulation violates the negative commerce clause. At the heart of the matter is the lack of standards for sharing among states. There is no core concept, like access to forums to express ideas, on which the Court can fall back.[38] "Free trade" is too simplistic to describe the current course of state and federal economic policies. Any attempt to reduce to a doctrinal formula what level of sharing is essential to the preservation of the federal union is bound to be arbitrary. Why is it that a state must share access to waste management sites but not to state-manufactured cement?[39]

The Court has attempted to define its role in deciding whether state regulation is inconsistent with national interests in interstate commerce by a two-level analysis. First, statutes that facially discriminate against interstate commerce or citizens of another state are almost per se invalid.[40] The standard applied is strict scrutiny. Second, non-facially discriminatory legislation is subject to a balancing test that requires the strength of the local interest to be identified and weighed against national interests.

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[36] 336 U.S. 525 (1949).

[37] Brown, *The Open Economy: Justice Frankfurter and the Position of the Judiciary*, 67 Yale L.J. 219 (1957). For a recent articulation of this justification, see J. Choper, Judicial Review and the National Political Process 205-09 (1980).

[38] Justice Frankfurter made an unsuccessful attempt to enunciate such a standard in his concurring opinion in Toomer v. Witsell, 334 U.S. 385, 409 (1948) (Frankfurter, J., concurring).

[39] *Compare* City of Philadelphia v. New Jersey, 437 U.S. 617 (1978) *with* Reeves, Inc. v. Stake, 447 U.S. 429 (1980).

Since *Pike v. Bruce Church*,[41] the Court has adhered to this analysis, which is a refinement of Justice Stone's *Southern Pacific Co. v. Arizona*[42] balancing test. According to *Pike:*

> Although the criteria for determining the validity of state statutes affecting interstate commerce have been variously stated, the general rule that emerges can be phrased as follows: Where the statute regulates even-handedly to effectuate a legitimate local public interest, and its effects on interstate commerce are only incidental, it will be upheld unless the burden imposed on such commerce is clearly excessive in relation to the putative local benefits. Huron Cement Co. v. Detroit, 362 U.S. 440, 443. If a legitimate local purpose is found, then the question becomes one of degree. And the extent of the burden that will be tolerated will of course depend on the nature of the local interest involved, and on whether it could be promoted as well with a lesser impact on interstate activities.[43]

The test has the merits of candor and conciseness, but it is open to the criticism that the factors balanced give insufficient weight to legitimate state interests. For example, the Court had long held that a state had the power to impede interstate commerce through the imposition of quarantine or other public health laws, but in *City of Philadelphia v. New Jersey*[44] the Court applied the negative commerce clause doctrine to require New Jersey to take its fair share of wastes generated out of state.

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[40] Hellerstein, *Hughes v. Oklahoma: The Court, The Commerce Clause, and State Control of Natural Resources*, 1979 SUP. CT. REV. 51, 59.

[41] 397 U.S. 137 (1970). *See also* Hunt v. Washington State Apple Advertising Comm'n, 432 U.S. 333 (1977).

[42] 325 U.S. 761 (1945).

[43] 397 U.S. at 142.

[44] 437 U.S. 617 (1978). *Accord* Washington State Bldg. and Constr. Trades Council v. Spellman, 18 ERC 1073 (9th Cir. 1982).

City of Philadelphia is especially troubling because it uses the negative commerce clause to invalidate state legislation where the state interests are quite strong and the problem is part of a larger problem that is being addressed at the national level. Congress has passed extensive legislation to regulate the transportation and treatment, storage, and disposal of hazardous and other wastes. But Congress and the Environmental Protection Agency have chosen to leave waste disposal-siting issues to the states. Thus, it is not clear that the Supreme Court's insistence that all states take their fair share of wastes correctly reflects national policy.[45] Moreover, whether the Constitution compels the acceptance[46] of interstate wastes or other evils is even more doubtful.

A more sensible rule, sanctioned by Justice Holmes' opinion in *Georgia v. Tennessee Copper*,[47] is a presumption of a state right of self-help until preempted by Congress. The Court has had a difficult time applying the proper standards to test state legislative motivation and state interest in routine interferences with interstate commerce. Consequently, there is very little basis for optimism that Supreme Court decisions invalidating state legislation in areas such as slurry bans and environmental protection statutes will articulate basic national policies in a fashion superior to that of the legislative process.[48]

D. The Rise and Fall of the Special Status of Natural Resources Under the Commerce Clause: Ownership of Western Waters

To shore up their claims to resource sovereignty, the western states have long argued that they alone could control the allocation of their waters because they "owned them in trust for the public." This argument is nothing more than an assertion of the police power, but for years the western states argued that this ownership made water unique in the sense that it was immune from regulation under the federal Constitution. Long after the issue of affirmative federal power was settled, the uniqueness argument lived on in the negative commerce clause. Until *Sporhase,* the states clung to the slim, unreasonable hope that the Court would adhere to early precedents and affirm the uniqueness of water. The reason was that the Supreme Court began its application of the negative commerce clause to resource embargo statutes with a sweeping theory upholding them.

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[45] *See* Tarlock, *Anywhere But Here: An Introduction to State Control of Hazardous Waste Facility Location*, 2 U.C.L.A. J. ENVTL. L. & POL'Y 1 (1982).

[46] City of Philadelphia v. New Jersey, 437 U.S. at 628-29 (1978). Justice Stewart did say, in dictum, that "it may be assumed . . . that New Jersey may pursue those ends [pollution prevention] by slowing the flow of all waste into the state's remaining land fills, even though interstate commerce may incidentally be effected." *Id.* at 626.

[47] Georgia v. Tennessee Copper Co., 206 U.S. 230 (1907).

[48] An analogous issue in the energy area is state mineral severance taxes. The Court recently upheld Montana's 30% tax against a commerce clause challenge in Commonwealth Edison Co. v. Montana, 450 U.S. 991 (1981),

In the foundation case *Geer v. Connecticut,*[49] the Court rejected a commerce clause challenge to a statute that prohibited the interstate transportation of game birds lawfully killed within the state. *Geer* capped a remarkable development of the Roman law conceptions of things *ferae naturae* and *res nullius,* things in the negative community awaiting capture. The Roman notion that everything had to be assigned to someone was a perfect justification for the use of the principle of capture to recognize private rights in common pool resources such as oil and gas and water. Roman law was also elastic enough to serve as a basis for state conservation legislation at a time when the claim that the state had the power to decide, by virtue of its police power, who would capture what and under what conditions was constitutionally suspect. In Roscoe Pound's famous words:

> We are also tending to limit the idea of discovery and occupation by making res nullius (e.g., wild game) into res publicae and to justify a more stringent regulation of individual use of res communes (e.g., of the use of running water for irri-

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and Professor Stephen Williams has developed a rationale similar to that stated in the text here for the Court's decision. Williams, *Severance Taxes and Federalism: The Role of the Supreme Court in Preserving a National Common Market for Energy Supplies,* 53 U. COLO. L. REV. 281, 309-13 (1982).

[49] 161 U.S. 519 (1896).

> gation or for power) by declaring that they are the property of the state or are "owned by the state in trust for the people." It should be said, however, that while in form our courts and legislatures seem thus to have reduced everything but the air and the high seas to ownership, in fact the so-called state ownership of res communes and res nullius is only a sort of guardianship for social purposes. It is imperium, not dominium.[50]

Geer went beyond this use of Roman law. Not only did the Supreme Court accept without question the argument that the statute was an appropriate food conservation statute, but it suggested that resources owned in trust by the state could never become part of interstate commerce "except with the consent of the state and subject to the conditions which it may deem best to impose for the public good."[51]

Geer was directly applied to water export bans in *Hudson County Water Co. v. McCarter.*[52] Justice Holmes was too good a jurist to use the state title fiction; instead, he sustained the New Jersey statute banning the export of water on the broader theory of state sovereignty over resources:

> It sometimes is difficult to fix boundary stones between the private right of property and the police power when, as in the case at bar, we know of few decisions that are very much in point. But it is recognized that the State as quasi-sovereign and representative of the interests of the public has a standing in court to protect the atmosphere, the water and forests within its territory, irrespective of the assent or dissent of the private owners of the land most immediately concerned. What it may protect by suit in this court from interference in the name of property outside of the State's jurisdiction, one would think that it could protect by statute from interference in the same name within.

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[50] R. POUND, AN INTRODUCTION TO THE PHILOSOPHY OF LAW 111 (1954 Yale U. Press ed.). The state ownership theory as justification for exclusive state power to allocate its water is generally traced to Farm Inv. Co. v. Carpenter, 9 Wyo. 110, 61 P. 258 (1900).

[51] 161 U.S. at 535.

[52] 209 U.S. 349 (1908). *See also* McCready v. Virginia, 94 U.S. 391 (1876).

> The problems of irrigation have no place here. Leaving them on one side, it appears to us that few public interests are more obvious, indisputable and independent of particular theory than the interest of the public of a State to maintain the rivers that are wholly within it substantially undiminished, except by such drafts upon them as the guardian of the public welfare may permit for the purpose of turning them to a more perfect use. This public interest is omnipresent wherever there is a State, and grows more pressing as population grows. It is fundamental, and we are of opinion that the private property of riparian proprietors cannot be supposed to have deeper roots.[53]

Geer was flawed from the start because the theory of state ownership swept too broadly. Given the reach of the negative commerce clause, no state assertion of regulatory power can be immune from judicial scrutiny to determine its effect on interstate commerce and the risk to the continued validity of the federal union. *Geer* was substantially undermined in *Oklahoma v. Kansas Natural Gas Company*[54] and in subsequent opinions, but it survived formally until 1979.

Oklahoma v. Kansas National Gas Company arose because Oklahoma passed a statute forbidding the interstate transportation of natural gas. The state defended its legislation on the strongest of necessity grounds: Oklahoma was the fastest growing state in the country; it was without domestic fuel except coal, which was becomnig more costly to produce; it was dependent on natural gas because almost all of its oil was transported out of state; and as a result, certain cities next to gas fields "should be supplied with gas, are not now supplied with it, and will never be if complainants are allowed to transport it from Oklahoma."[55] Over the dissents of Justices Holmes, Lurton and Hughes, the Court held that the statute violated the commerce clause.

Geer was not directly discussed; instead the Court began its analysis with the seminal oil and gas conservation case, *Ohio Oil Co. v. Indiana.*[56] *Ohio Oil* sustained the first state effort to conserve natural gas supplies by banning well flaring. Indiana had tried to circumvent Ohio Oil's claim that the ban interfered impermissibly with the company's right to dispose of its gas as it chose by arguing that oil and gas were *ferae naturae* and thus never owned by the company prior to reduction to possession. Justice White rejected this argument on the ground that oil and gas were not truly analogous to things *ferae naturae* because the right to capture had been assigned to a limited class of property owners — those who owned land overlying a common source of supply. The statute was sustained, however, on the narrow, but innovative theory that it was an exercise of the state's power to protect the correlative rights of those property owners, which included a fair opportunity to capture a reasonable share of the supply.

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[53] Hudson County Water Co. v McCarter, 209 US. at 355-56 (1908) (citations omitted). *Accord* Pennsylvania v. West Virginia, 262 U.S. 553 (1923).
[54] 221 U.S. 229 (1911).
[55] *Id.* at 246.

In *Oklahoma* the Court concluded that the embargo was bad precisely because it did not protect the correlative rights of property owners but rather reserved resources for the future use of state residents. Gas, the Court stated, when reduced to possession, was clearly an article of interstate commerce. The purpose of the statute, the Court found, was commercial rather than physical conservation; therefore the statute violated the commerce clause because it undermined the concept of a federal system bound together by free trade:

> In other words, the purpose of its conservation is in a sense commercial — the business welfare of the State, as coal might be, or timber. Both of those products may be limited in amount, and the same consideration of the public welfare which would confine gas to the use of the inhabitants of a State would confine them to the inhabitants of the State. If the States have such power a singular situation might result. Pennsylvania might keep its coal, the Northwest its timber, the mining States their minerals. And why may not the products of the field be brought within the principle? Thus enlarged, or

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[56] 177 U.S. 190(1900).

> without that enlargement, its influence on interstate commerce need not be pointed out. To what consequences does such power tend? If one State has it, all States have it; embargo may be retaliated by embargo, and commerce will be halted at state lines.[57]

McCarter was discussed and distinguished on several weak grounds. The strongest was that the common law of riparian rights did not allow diversion to non-riparian land. Today this view prevails in its strict form in very few states. Furthermore, the Court has recognized the power of states to enter into interstate compacts which might limit private water rights. The suggestion in *McCarter*, repeated in *Oklahoma*, that the export ban did little more than preserve private correlative rights is therefore too broad, because the private rights protected may be substantially modified pursuant to an interstate compact or decree of equitable apportionment. Justice Holmes perhaps anticipated this weakness and ultimately rested his opinion in the case on the state's power to preserve its natural advantage.[58] The *Oklahoma* Court could only deal with Holmes' analysis by arbitrarily concluding that natural gas was a less important resource than a flowing river: "And surely we need not pause to point out the difference between such a river flowing upon the surface of the earth and such a substance as gas seeping invisibly through sands beneath the surface."[59] It is hard to see why.

Since *Oklahoma v. Kansas Natural Gas Company*, the Court has adhered to its vision of the resource embargo causing a complete breakdown of interstate commerce in its analysis of export bans. For example, in 1982, the Court in *New England Power Co. v. New Hampshire*[60] unanimously invalidated an order of the New Hampshire Public Service Commission revoking previously granted permission for a utility to transport hydroelectric energy generated within the state to traditional areas of high demand in New England. Chief Justice Burger contemptuously wrote off the statute as "simple economic protectionism."[61]

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[57] 221 U.S. at 255.

[58] Justice Holmes applied his views of state sovereignty in the foundation case recognizing a common law of nuisance. Georgia v. Tennessee Copper Co., 206 U.S. 230 (1907). It is ironic that Justice Rehnquist, who dissented in *Sporhase* along the lines of Justice Holmes' theory of state power, wrote the opinion in City of Milwaukee v. Illinois, 451 U.S. 304 (1981). *Milwaukee* reversed Illinois v. Milwaukee, 406 U.S. 91 (1972), which had held that the Federal Water Pollution Control Act did not preempt the federal common law of nuisance. *Milwaukee* held that the Clean Water Act, enacted a year after *Illinois* was decided, did preempt the common law of nuisance. This is bad law and bad policy, but relief will have to come from Congress.

[59] 221 U.S. at 260.

Despite the flawed analysis of state power in *Geer*, western states clung tenaciously to the ownership fiction for two reasons. First, the states asserted ownership as a basis for denying federal proprietary rights, although this effort failed. The Supreme Court is committed to the doctrine of federal reserved water rights, and few doubt the constitutional basis of the federal government's power.[62] Second, since the mid-1960's there have been plans afoot for massive inter-basin water transfers. In most cases the political and economic costs of these projects carry their own death wound in the form of an unfavorable benefit-cost analysis, but more modest inter-basin diversions, such as coal slurry pipelines, may be cost-justified. To prevent all inter-basin transfers, the states have urged the *Geer* rule and its application in *McCarter*. This argument was doomed to failure as it is nothing more than an ineffective assertion of the state's police power;[63] the only remarkable thing is that *Geer* formally lasted until 1979 and *McCarter* lingered until 1982.

Geer finally fell in *Hughes v. Oklahoma*.[64] At issue was the epic question of whether Oklahoma could prohibit the transport of natural minnows "seigned or procured within the waters of the state."[65] Writing for a seven member majority, Justice Brennan traced the demise of *Geer's* formalistic[66] ownership analysis and concluded "that challenges under the Commerce Clause to state regulations of wild animals should be considered according to the same general rule applied to state regulations of other natural resources . . .";[67] he then expressly overruled *Geer*.

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[60] ...... U.S. ......, 102 S.Ct. 1096 (1982). The more interesting issue was whether Congress had authorized export bans in section 201(b) of the Federal Power Act. It seems clear that this section was drafted to preserve New Hampshire's right under the 1913 statute. The Court agreed that Congress could authorize barriers to interstate commerce but found that Congress merely left standing existing laws banning the export of hydroelectricity and did not intend to suspend the negative commerce clause. *See, e.g.*, Prudential Ins. Co. v. Benjamin, 328 U.S. 408 (1946).

[61] New England Power Co. v. New Hampshire, 102 S.Ct. at 1101 (1982) (quoting City of Philadelphia v. New Jersey, 437 U.S. at 624 (1978)).

[62] *See* Trelease, *Arizona v. California: Allocation of Water Resources to People, States and Nation*, 1963 SUP. CT. REV. 158.

[63] The argument was laid to rest in Dean Trelease's classic article, *Government Ownership and Trusteeship of Water*, 45 CALIF. L. REV. 638 (1957).

[64] 441 U.S. 322 (1979).

Applying the Court's reasoning in *Pike v. Bruce Church, Inc.*,[68] Justice Brennan subjected the statute to the "strictest scrutiny" because it was facially discriminatory, and found it invalid. The state put forward a modern conservation argument to the effect that it wanted to preserve the ecological balance of its waters by preventing the removal of an inordinate number of natural minnows, but this justification was found to be an insufficient, although legitimate, state interest. The Court stated that the fiction of state ownership could no longer be used to force those outside the state to bear the full costs of " 'conserving' the wild animals within its borders when equally effective nondiscriminatory conservation measures are available":[69]

> Far from choosing the least discriminatory alternative, Oklahoma has chosen to "conserve" its minnows in the way that most overtly discriminates against interstate commerce. The State places no limits on the numbers of minnows that can be taken

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[65] OKLA. STAT. tit. 29, § 4-115(B) (Supp. 1978).

[66] 411 U.S. at 328. *Geer* was in effect overruled in Toomer v. Witsell, 334 U.S. 385 (1948). The Court used both the privileges and immunities and commerce clauses to strike down legislation that discriminated against out-of-state fishermen. With respect to the commerce clause, the Court wrote:

> The whole ownership theory, in fact, is now generally regarded as but a fiction expressive in legal shorthand of the importance to its people that a State have power to preserve and regulate the exploitation of an important resource. And there is no necessary conflict between that vital policy consideration and the constitutional command that the State exercise that power, like its other powers, so as not to discriminate without reason against citizens of other States.

Id. at 402.
Toomer was recently followed and applied in Douglas v. Seacoast Products, Inc., 431 U.S. 265 (1977).
Inc., 431 U.S. 265 (1977).

[67] 441 U.S. at 335.

[68] 397 U.S. 137, 142 (1970).

[69] 441 U.S. at 337.

> by licensed minnow dealers; nor does it limit in any way how these minnows may be disposed of within the State. Yet it forbids the transportation of any commercially significant number of natural minnows out of the State for sale. Section 4-115(B) is certainly not a "last ditch" attempt at conservation after nondiscriminatory alternatives have proved unfeasible. It is rather a choice of the most discriminatory means even though nondiscriminatory alternatives would seem likely to fulfill the State's purported legitimate local purpose more effectively.[70]

The state of Oklahoma attracted only the votes of Chief Justice Burger and the new guardian of Western state interests, Mr. Justice Rehnquist. The dissent accepted the majority's analysis up to the point where it downgraded the state's conservation interest. To Mr. Justice Rehnquist, the fear-of-Balkanization argument relied on by Justice Brennan supported only the invalidation of statutes that conflict with a federal statute or treaty or represent "a naked attempt to discriminate against out-of-state enterprises in favor of in-state businesses unrelated to any purpose of conservation."[71] He distinguished Oklahoma's statute from the long line of cases striking down statutes, palmed off as conservation measures, that protected in-state businesses from out-of-state competition. Given what he saw as the statute's evenhandedness, he found the burden on interstate commerce to be minimal and the state's conservation interest substantial:

> Oklahoma does regulate the manner in which both residents and nonresidents procure minnows to be sold outside the State. But there is no showing in this record that requiring appellant to purchase his minnows from hatcheries instead of from persons licensed to seine minnows from the State's waters in any way increases appellant's costs of doing business. . . . So far as the record before us indicates, hatchery minnows and naturally seined

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[70] *Id.* at 337-38 (citations and footnotes omitted).

[71] *Id.* at 342 (Rehnquist, J., dissenting). *See, e.g.*, Toomer v. Witsell, 334 U.S. 385 (1948); Foster Packing Co. v. Haydel, 278 U.S. 1 (1928); Johnson v. Haydel, 278 U.S. 16 (1928).

> minnows are fungible. Accordingly, any minimal burden that may result from requiring appellant to purchase minnows destined for sale out of state from hatcheries instead of from those licensed to seine minnows is, in my view, more than outweighed by Oklahoma's substantial interest in conserving and regulating exploitation of its natural minnow population.[72]

Negative commerce clause decisions reflect a high level of doctrinal consistency and predictability. However, they are increasingly being criticized. The *Pike* test emerges upon closer examination as just another version of the largely discredited theory of substantive due process.[73] It is not surprising that those uncomfortable with the difficulty of distinguishing the discredited notion of substantive due process from the Court's commerce clause analysis have turned to alternative approaches to justify the Court's role in this aspect of federalism.

To some, a revived theory of privileges and immunities is the answer.[74] Others have been influenced by Dean John Hart Ely's *Democracy and Distrust* and have sought a process-based approach that seeks the important but more limited goal of curing serious malfunctions in the representative process. An approach based on this theory replaces the Court's balancing test with a four part test; to determine whether a statute offends the negative commerce clause, a court should inquire whether (1) the end is legitimate, (2) the statute has a disproportionate impact on nonrepresented interests, (3) the legislation is likely to achieve its goal, and (4) the legislature has chosen the least restrictive means of implementing its goal in light of the heavy impact on nonrepresented entities.[75]

The Ely-influenced test holds the promise of possible constitutionality for some embargoes, because it relaxes rules that result in findings of per se invalidity and it validates state laws that do not foreclose access to the political process: "The representation-enforcing approach commands judicial intervention where the mechanisms of participatory government have failed to operate, but it also requires deference where no such defect appears."[76] It also offers a way out of the motives trap into which the Court has fallen under the present test.[77] In the final section of this paper, the implications of this approach for western water embargoes are explored.

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[72] 441 U.S. at 345-46.

[73] *See* Kitch, *Regulation and the American Common Market*, in REGULATION, FEDERALISM AND INTERSTATE COMMERCE 29-36 (A. Tarlock ed. 1981).

[74] *See* Varat, *State "Citizenship" and Interstate Equality*, 48 U. CHI. L. REV. 487 (1981). *See also* Anson and Schenkkan, *Federalism, the Dormant Commerce Clause, and State-Owned Resources*, 59 TEXAS L. REV. 71 (1980).

[75] Eule, *Laying the Dormant Commerce Clause to Rest*, 91 YALE L.J. 425 (1982).

E. *Sporhase v. Nebraska ex. rel Douglas:*[78] Is Western Water No Longer Unique?

In 1982 the second precedential pillar of the western states' "ownership" argument fell. *Sporhase v. Nebraska*[78] effectively overruled *McCarter* and held that a Nebraska groundwater export ban violated the negative commerce clause. On one level *Sporhase* is simply another in the growing line of Supreme Court cases clearing away nineteenth century fictions thought to be inconsistent with free trade. However, Justice Stevens' opinion demonstrates more sensitivity to the arid states' interests in water policy than one might expect after *Hughes* and other recent natural resources commerce clause cases and suggests that some export bans might be constitutional. Further, the opinion suggests, at a minimum, other means by which the western states can constitutionally achieve the objectives reflected in such statutes.

The facts of *Sporhase* made the case a relatively easy one and therefore do not necessarily foreclose a different result where the state's interest is stronger. Nebraska required a permit for the interstate diversion of groundwater. The Director of the Department of Natural Resources had to find that the withdrawal was "reasonable" and "not otherwise detrimental to the public welfare" and that the host state "grant[ed] reciprocal rights to withdraw and transport groundwater from that state for use in the State of Nebraska."[79] A farmer on the Colorado border who owned contiguous tracts of land in both states acted as would any single rational landowner and shifted water from a Nebraska well to the Colorado portion of his land when that land required water. But, he failed to apply for the permit required by Nebraska law, and the state sued to enjoin the interstate transfer.

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[76] *Id.* at 442. For a democratic defense of the Court's current role, see Gibson, *Constitutional Adjudication and Democratic Theory*, 56 N.Y.U. L. REV. 260, 265 (1981).

[77] *Compare* Kassel v. Consolidated Freightways Corp., ... U.S. ...., 101 S.Ct. 1309 (1981) *with* Raymond Motor Transp., Inc. v. Rice, 434 U.S. 429 (1978). *See The Supreme Court, 1980 Term*, 95 HARV. L. REV. 17, 93-102 (1981).

[78] .... U.S. ...., 102 S.Ct. 3456 (1982).

Both the trial court and the Nebraska Supreme Court held that the statute did not impose an undue burden on interstate commerce.[80] The supreme court based its decision on the conclusion that a groundwater right was not "a marketable item freely transferable for value among private parties, and therefore [is] not an article of commerce."[81] This allowed the court to distinguish the enigmatic case of *City of Altus v. Carr*.[82] The court in *City of Altus* followed *Oklahoma v. Kansas Natural Gas Co.* to strike down Texas legislation, which was similar to Nebraska's, as an undue burden on interstate commerce. The United States Supreme Court affirmed summarily, and there has been considerable speculation ever since over the reach of the decision.[83]

To the Nebraska Supreme Court, the crucial issue was the difference between a Texas and a Nebraska groundwater right. Texas, until recently, followed the classic English rule that allowed unlimited, even wasteful,[84] pumping of groundwater for use on overlying or non-overlying land provided that the purpose was not malicious. Nebraska is an appropriation state for surface water but not for groundwater. A Nebraska groundwater right, like a Texas one, is based on overlying land ownership, but the state legislature and courts have placed significant restrictions on its use compared to those imposed in Texas. Groundwater users in Nebraska have some right to a fair share of a pool,[85] and the state has natural resources districts and management districts that limit pumping levels in areas of actual or potential overdraft.[86] This distinction, however, even if correct cannot be an answer to a commerce clause challenge, if for no other reason than that the statute prohibits interstate transportation of water after it has been extracted from the ground and has thus become the personal property of the diverter.

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[79] NEB. REV. STAT. § 46-613.01 (Reissue 1978).
[80] 208 Neb. 703, 305 N.W.2d 614 (1981).
[81] *Id.*, 305 N.W.2d at 616.
[82] 255 F. Supp. 828 (W.D. Tex.), *aff'd mem.*, 385 U.S. 35 (1966).
[83] *See, eg.*, Corker, *supra* note 11.
[84] City of Corpus Christi v. City of Pleasanton, 154 Tex. 289, 276 S.W.2d 798 (1955). In Friendswood Dev. Co. v. Smith-Southwest Indus., 576 S.W.2d 21 (Tex. 1978), the Texas Supreme Court prospectively modified its adherence to the English rule that allows a landowner injured by subsidence to show that the pumper's use pattern negligently caused the injury.

Hughes v. Oklahoma removed the conceptual underpinnings from the state's ownership argument by overruling *Geer*. Justice Stevens dealt the coup de grace to state ownership arguments in *Sporhase* by holding that *Hughes* overruled *McCarter* by implication, and by brushing aside the proffered distinction between water and minnows:

> Although appellee's greater ownership interest may not be irrelevant to Commerce Clause analysis, it does not absolutely remove Nebraska ground water from such scrutiny. For appellee's argument is still based on the legal fiction of state ownership. The fiction is illustrated by municipal water supply arrangements pursuant to which ground water is withdrawn from rural areas and transferred to urban areas. Such arrangements are permitted in Nebraska, but the Nebraska Supreme Court distinguished them on the ground that the transferor was only permitted to charge as a price for the water his costs of distribution and not the value of the water itself. Unless demand is greater than supply, however, this reasoning does not distinguish minnows, the price of which presumably is derived from the costs of seining and of transporting the catch to market. Even in cases of shortage, in which the seller of the natural resource can demand a price

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[85] Prather v. Eisenmann, 200 Neb. 1, 261 N.W.2d 766 (1978).

[86] *See* Aiken, *Nebraska Ground Water Law and Administration*, 59 NEB. L. REV. 917 (1980).

> that exceeds his costs, the State's rate structure that requires the price to be cost-justified is economically comparable to price regulation. A State's power to regulate prices or rates has never been thought to depend on public ownership of the controlled commodity.[87]

There is little that should surprise western water lawyers in the Court's conclusion that water rights are an article of commerce because of the interstate effects of state water allocation choices. This is perfectly illustrated by the fact that *Sporhase* involved the Ogallala aquifer. Western water rights are no different from Arizona cantaloupes[88] or North Carolina apples.[89] The existence of federal power over waters was conclusively established in *Arizona v. California.*[90] As Justice Stevens recognized in *Sporhase*, a contrary conclusion "would curtail the affirmative power of Congress to implement its own policies."[91]

To say that water is an article of interstate commerce is not to conclude that a state export statute impermissibly burdens interstate commerce. The Court, in *Sporhase*, did find such a burden, but the majority's application of the *Pike v. Bruce Church, Inc.*[92] test leaves western states with some room to maneuver. Nebraska's statute failed to pass muster because the stand-off between the two state reciprocity statutes operated "as an explicit barrier to [interstate] commerce" and the statute failed to demonstrate "a close fit between the reciprocity requirement and its asserted local purpose."[93] Nebraska's sole justification for the statute — conservation — was bound to be overbroad because the state straddles the line between humidity and aridity. States entirely west of the 98th meridian, however, may take hope from the following language:

> The Western States' interests, and their asserted superior competence, in conserving and pre-

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[87] 102 S.Ct. at 3462 (citations omitted).

[88] *See* Pike v. Bruce Church, Inc., 397 U.S. 137 (1970).

[89] *See* Hunt v. Washington State Apple Advertising Comm'n, 432 U.S. 333 (1977).

[90] 373 U.S. 546 (1963).

[91] 102 S.Ct. at 3463.

[92] 397 U.S. 137 (1970).

[93] 102 S.Ct. at 3465.

> serving scarce water resources are not irrelevant in the Commerce Clause inquiry. Nor is appellee's claim to public ownership without significance. Like Congress' deference to state water law . . . these factors inform the determination whether the burdens on commerce imposed by state ground water regulation are reasonable or unreasonable. . . . If it could be shown that the State as a whole suffers a water shortage, that the intrastate transportation of water from areas of abundance to areas of shortage is feasible regardless of distance, and that the importation of water from adjoining States would roughly compensate for any exportation to those States, then the conservation and preservation purpose might be credibly advanced for the reciprocity provision. A demonstrably arid state conceivably might be able to marshall evidence to establish a close means-end relationship between even a total ban on the exportation of water and a purpose to conserve and preserve water.[94]

Two of the three westerners on the Court, Mr. Justice Rehnquist and Mme. Justice O'Connor, dissented. Mr. Justice Rehnquist's point was that a groundwater right in Nebraska was "only a usufructory right," so it could not be said that " 'commerce' in groundwater exists as far as Nebraska is concerned."[95] He distinguished *Hughes* as a case where the state had allowed a natural resource to be reduced to private possession:

> By contrast, Nebraska so regulates groundwater that it cannot be said that the State permits any "commerce," intrastate or interstate, to exist in this natural resource. As with almost all of the Western States, Nebraska does not recognize an absolute ownership interest in groundwater, but grants landowners only a right to *use groundwater on the land from which it has been extracted.* Moreover, the landowner's right to use groundwater is limited. Nebraska landowners may not extract groundwater "in excess of a reasonable and beneficial use upon the land in which he owns, especially

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[94] *Id.* at 3463, 3465.
[95] *Id.* at 3468-69.

> if such use is injurious to others who have substantial rights to the waters, and if the natural underground supply is insufficient for all owners, each is entitled to a reasonable proportion of the whole." With the exception of municipal water systems, Nebraska forbids any transportation of groundwater off the land owned or controlled by the person who has apropriated the water from its subterranean source.[96]

Justice Rehnquist's argument is either based on a fundamental misconception of the relationship between the commerce clause and state property law or the Justice seeks to return to the days when commerce clause law consisted of fictions on fictions. His attempt to characterize the Nebraska groundwater statute as exempt from the commerce clause because the right to use has been limited, fails because the analysis potentially applies to all common pool property rights. Private rights to use common pool resources are, of necessity, less complete that those in other resources, but incomplete or shared rights are no less property because they are "only . . . usufructory right[s]."[97]

Today all property rights, common pool or exclusive, are limited by the state's exercise of its police powers. There is no difference between a Nebraska groundwater right limited to use on underlying land and a tract of fee simple absolute land in Lincoln, the use of which is limited by a stringent zoning ordinance that prevents a factory from relocating there from out of state. In each case the issue is the same: has the state enacted a law that is inconsistent with the policies implicit in the negative commerce clause? To use a more realistic example, surely a state could not defend a statute prohibiting the burial of hazardous or low-level nuclear wastes simply because state law prohibited the use of land for that purpose. The constitutional problem cannot be simplified by adopting old categories of property rights.

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[96] *Id.* (emphasis in original) (citation omitted)(quoting Olson v. City of Wahoo, 124 Neb. 802, 811, 248 N.W. 304, 308 (1933)).

[97] *Id.* at 3468.

Moreover, the characterization of Nebraska water law is too extreme. The state does not absolutely tie, as do some appropriation states, a water right to the land. The meaning of *Olson v. City of Wahoo,* cited by Justice Rehnquist in his dissent, has long been disputed within the state. It is either an adoption of the California correlative rights rule or it is an adaptation of the modern rule of riparian rights that allows non-riparian uses so long as other riparians are not injured. Under either of these options, the result is not to prohibit absolutely the use of groundwater on non-overlying land. Rather, uses on overlying land are only given a preference over uses on non-overlying land. Finally, there is no clear state administrative policy prohibiting groundwater transfers.[98]

F. Export Bans After *Sporhase:* Are All Bans Invalid?

What does *Sporhase* mean for other western state water embargoes? *Sporhase* confirms the heavy burden states bear to justify anti-slurry and related legislation. The states can no longer claim that state trust ownership or other distinctive features of western water law allow the states to unilaterally exclude water resources from commerce clause scrutiny. It is equally clear that state trust ownership does not give the states a tenth amendment claim that federal intervention is inconsistent with essential attributes of state sovereignty.[99]

The issue is whether the burden on interstate commerce is impossible to justify, and, if it is, what other options remain open to the state. The last question is answered easily. *Sporhase* reaffirmed the principle of *Prudential Insurance Company v. Benjamin*[100] that Congress can exempt state legislation from commerce clause review. The standards for congressional consent are strict[101] and the limits of *Benjamin* have never been defined, but political protection of their interests remains open to the western states.

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[98] *See* Aiken, *supra* note 86, at 986-87. Nebraska is often described as a state that does not permit transfers of water. The issue, however, is much more complicated. *See* HUTCHINS, 1 WATER RIGHTS LAWS IN THE NINETEEN WESTERN STATES 463-66 (1971).

[99] State of Minnesota *by Alexander* v. Block, 660 F.2d 1240, 1251-53 (8th Cir. 1981). *But see* Hellerstein, *supra* note 40, at 77. *Compare,* Varat, *supra* note 74, at 556-57.

[100] 328 U.S. 408 (1946).

To many, the availability of congressional relief, which the western states have used effectively with respect to water resources policy generally, is a sufficient answer to state interests in export barriers. This is a powerful argument, but I think that *Sporhase* provides some basis for concluding that a more strongly justified export ban might be sustained absent congressional consent. In this final section, I will examine the impact of the decision on slurry and other export bans and suggest the arguments that might be open to the western states under a generous, admittedly creative, reading of *Sporhase.*

1. The Per Se and Reciprocity Export Bans

Colorado, Montana, New Mexico, Nevada, and Washington[102] have either per se or reciprocal export bans. All of these statutes are presumptively invalid under *Sporhase.* New Mexico, Nevada, and perhaps Colorado might be able to argue that they suffer from a chronic statewide, as opposed to a regional, water shortage. Montana's special anti-slurry statute[103] does not discriminate on its face against interstate commerce, but its discriminatory effect is clear and it will probably be treated as a per se export ban under *Sporhase.* The state will have trouble showing the compelling statewide need for the water that was required by the Court's opinion in *Sporhase.*

2. Legislative Approval

Oregon, South Dakota, and Wyoming[104] require legislative approval for major interstate diversions. These statutes do not per se discriminate against interstate commerce. In fact, they contemplate, at least on their face, substantial interstate diversions. South Dakota might argue that its system making state appropriations available for sale to slurry pipelines and other energy developers[105] merely represents a decision by the state to enter the resource market and capture for the public the benefits of state owned resources, as in *Reeves, Inc. v. Stake*,[106] where the Supreme Court held that the state could give in-state residents a preference in purchasing state-manufactured cement. This would be an intriguing argument but its success is open to considerable doubt. In *Reeves*, the Court went out of its way to distinguish cement from natural resources, especially scarce ones, and the rationale for the decision is less than compelling.[107]

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[101] New England Power Co. v. New Hampshire, ____ U.S. ____, 102 S.Ct. 1096 (1982).

[102] *See supra* notes 25, 20, 19, 23 and 24.

[103] *See supra* note 20. *But see* Comment, *supra* note 20, at 169 (which argues that the statute should be sustained because "[t]he construction of one slurry line could significantly interfere with alternative" future uses of water).

[104] *See supra* notes 28, 27 and 26.

The major problem that legislative approval schemes face is that the statute that was invalidated in *City of Altus v. Carr* conditioned out-of-state diversions on legislative approval. At a minimum, the state has subjected out-of-state users to higher standards than those required for in-state users and the burden of justifying such discrimination requires a substantial, although not compelling, demonstration of state interest.

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[105] South Dakota has adopted a water allocation scheme similar in concept to the California State Water Plan for interstate energy diversions. The State Board of Water and Natural Resources is authorized to apply to the regulatory agency, the Water Management Board, for an appropriation permit "to appropriate water for energy industry use for marketing to energy industry users for such consideration and under such terms and conditions as are fixed by contract or instrument of conveyance." S.D. Codified Laws Ann. § 46-17-18.1 (Supp. 1982). State appropriation applications are exempt from both the legislative approval and due diligence requirements of the general appropriation law. S.D. Codified Laws Ann. §§ 46-5-20.1 and 21.1 (Supp. 1982). In effect, South Dakota is claiming ownership of the water stored behind multipurpose dams on the Missouri River and offering the water for sale to the highest bidder. Downstream states have already threatened suit. The federal government's interest in navigation and flood control is also a factor to be considered.

[106] 447 U.S. 429 (1980).

[107] Varat, *supra* note 74, at 501-08. Professor Varat argues that the problem of resident versus nonresident interests can be best addressed through a theory of state citizenship derived from the privileges and immunities clause. To Professor Varat, the real issue in *Reeves* is not the regulatory-proprietary distinction drawn by the Court, but whether the state's monopoly power was sufficient to require a non-discriminatory access policy. *Id.* at 550-52. Some doctrinal justification for *Reeves* may be found in Baldwin v. Montana Fish and Game Comm'n, 436 U.S. 371 (1978), which distinguished between fundamental and non-fundamental rights claimed by out-of-state citizens.

3. The Least Restrictive Alternative Hurdle

In short, the arid states' efforts to validate export bans face a limited prospect for success. Money can make water run up hill, but it is not clear that legal arguments can accomplish the same result. *Sporhase* requires a close fit between the statute and a narrow conservation and preservation rationale. One creative argument is that such laws, as reverse quarantines, represent legitimate responses to emergencies, but this is not likely to be accepted by the Supreme Court after *City of Philadelphia v. New Jersey.* New Jersey tried to justify a law banning out-of-state solid wastes as a quarantine, but the seven member majority rejected the characterization. The Court narrowly defined quarantine as a situation where the articles had to be destroyed as soon as possible to prevent contagion and other evils. The problem with New Jersey's law was:

> There has been no claim here that the very movement of waste into or through New Jersey endangers health, or that waste must be disposed of as soon and as close to its point of generation as possible. The harms caused by waste are said to arise after its disposal in landfill sites, and at that point, as New Jersey concedes, there is no basis to distinguish out-of-state waste from domestic waste. If one is inherently harmful, so is the other. Yet New Jersey has banned the former while leaving its landfill sites open to the latter.[108]

Perhaps, Montana's legislation, since the use of all water for coal slurry is per se non-beneficial, might be presented as an evenhanded reverse quarantine, but I doubt it.

The major barrier that states face is that export bans are not the least discriminatory alternatives for conserving water resources. An attorney for Energy Transportation Systems, Incorporated has developed this argument at some length, and it is a powerful one.[109] On his list of nondiscriminatory alternatives are interstate compacts, denial of appropriations in the public interest, instream use appropriations or reservations, and the imposition of conditions on the right to change uses.

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[108] City of Philadelphia v. New Jersey, 437 U.S. at 629 (1978).

[109] Clyde, *supra* note 12, at 547-56 (emphasis in original).

The force of the requirement that states seek the least discriminatory means to achieve their ends, in the context of western water law, is that it forces the states to accept responsibility for something that they have been reluctant to do for political reasons; that is, to use their broad powers to allocate waters arising within their borders to further state interests regardless of the effect on interstate commerce.

In Justice Stevens' majority opinion in *Sporhase*, he went out of his way to confirm the power of states to act solely in their self-interest. He spoke of a state's powers "to conserve and preserve for its own citizens this vital resource in times of severe shortage" and to give a "limited preference for its own citizens."[110] The opinion can be read as a blueprint for the passage of laws that severely restrict access to water generally but will survive a negative commerce clause challenge. The statement "Obviously, a State that imposes severe withdrawal and use restrictions on its own citizens is not discriminating against interstate commerce when it seeks to prevent the uncontrolled transfer of water out of the state,"[111] will, ironically, sustain much more severe burdens on interstate commerce than those attempted by Nebraska.

At the same time, Justice Stevens seemed to be counseling the states to avoid ad hoc, hasty legislative judgments that are little more than a refusal to face the problem of how change can be accommodated, and which have the highest risk of offending the negative commerce clause. Instead, Justice Stevens would advise the states to concentrate on the development of balanced and comprehensive water policies. There is much truth in Dean Trelease's warning that water law alone should not be used to make decisions about regional growth. The law ought to return to its traditional function of setting the necessary conditions for the operation of the market, which include the forced absorption of the major external costs of reallocations.[112]

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[110] 102 S.Ct. at 3464.
[111] *Id.*

G. The Case for Export Bans After *Sporhase*

Despite the argument that export bans are not the least restrictive means of conserving a state's water resources, I think that there is still a role for them. The Court suggested in *Sporhase* that export bans might be necessary to conserve water in the arid west. In addition, bans could be analogized to interim zoning ordinances. A ban does not reflect a determination to preserve forever the status quo, but instead represents an effort by a state to buy breathing time in order to make more rational allocation decisions.

That argument was made and rejected in *City of Philadelphia*, but that case should not be viewed as dispositive of this argument. New Jersey tried to characterize its import ban statute as an effort to preserve existing in-state landfill capacity until the technology of waste management became more developed, so that the state might be able to avoid dedicating critical areas such as wetlands to waste disposal. The Court conceded that it might be proper for a state to slow "the flow of *all* waste into the State's remaining landfills, even though interstate commerce may incidentally be affected."[113] The rub was that the New Jersey statute discriminated against out-of-state wastes. Out-of-state commercial interests bore "the full burden of conserving the State's remaining landfill space."[114] In addition, New Jersey's legislative justification seemed post hoc.

The interim zoning ordinance analogy would be stronger if the current balancing test were replaced by an analysis that asks a different, more relevant question. Under the *Pike* balancing test the relevant factors are the evenhandedness of the statute, the relationship between the local interest and its impact on interstate commerce, and the feasibility of a less discriminatory alternative. This test is nothing more than a restatement of the much discredited, although occasionally revived, substantive due process approach. All of the faults of substantive due process can be found in the *Pike* approach.

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[112] Trelease, *Water Law, Policies, and Politics: Institutions for Decision Making* 199 in WESTERN WATER RESOURCES: COMING PROBLEMS AND THE POLICY ALTERNATIVES (1980).

[113] 437 U.S. at 626.

[114] *Id.* at 628.

A better approach would be to focus on the relationship between the state regulation and the likely risk of a malfunction in the political process. This approach is not unique to me and was inspired by Dean John Hart Ely's much discussed and controversial book, *Democracy and Distrust.*[115] Dean Ely mounts a defense of judicial review to protect those who are most likely to be the victims of majority control of legislative and administrative process. The use of the negative commerce clause to invalidate discriminatory legislation is a classic example of Ely's right-to-participate theory because in-state interests have failed to provide sufficient protection to voteless out-of-state interests.[116] The experience of many western water allocation conflicts suggests that the above test would not require judicial review for much water legislation. Often there is no denial of access to the political process at either the local or national level. Thus, the relevance of Ely's process-based approach for western water law is that it suggests a case against judicial interference in water allocation choices when the risks of a malfunction in the political process are low.

If a court did as suggested above, and examined the impact of the regulation on the challenger in terms of the disproportionate impact on non-represented interests and the likelihood of state or national legislative redress, statutes such as Wyoming's statute might pass muster. It is true that the statute imposes much of the cost of Wyoming's decision to preserve its waters for non-coal slurry uses on out-of-state citizens, but the state has expressly opened its legislature to these citizens to make the case for the use of water for this purpose. The legislature has not simply been used as a conduit for allowing in-state interests to gain a competitive advantage over out-of-state interests, which is the case in the usual negative commerce clause case.

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[115] J. ELY, DEMOCRACY AND DISTRUST: A THEORY OF JUDICIAL REVIEW (1980).
[116] *Id.* at 84.

Furthermore, if, as proponents claim, slurry pipelines are an essential element of national energy policy, then congressional relief is a real possibility.[117] The fact that Congress has considered legislation to give pipelines the right of eminent domain despite objections from the railroads, but to date has refused to preempt state water rights suggests that judicial intervention is not necessary to prevent economic balkanism. It is proper for courts to continue to inquire whether interim bans on the use of water for slurry are acceptable in light of less discriminatory alternatives, but the argument that such alternatives exist under traditional water law ought to have less force here because of the easy access to both the state and national political process.[118]

There is some justification for the continued use of the negative commerce clause to invalidate low-visibility encroachments on the national interest. However, I think that there is a valid distinction between low-visibility state regulations that do no more than favor local interests at the expense of interstate or national interests and state actions that are grounded in the protection of traditional interests, such as water allocation. The latter are entitled to a greater presumption of constitutionality because of the lower risk of a malfunction of the political process. There is still a role for judicial invalidation of low-visibility state regulations that impede national markets; the possibility of congressional preemption, no matter how remote, it not a reason for the Court to abdicate its traditional commerce clause role.[119] This caveat aside, statutes that seek to advance legitimate state interests and do more than interfere with the operation of the market by conferring a competitive advantage on in-state interests at the expense of out-of-state interests are entitled to greater deference by the courts regardless of the effect on interstate commerce.[120] This is especially true if the national interest is nothing more than an abstract notion of free trade.

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[117] *See* Comment, *supra* note 20.

[118] *See* Eule, *supra* note 75, at 460-68.

[119] Tushnet, *Darkness on the Edge of Town: The Contributions of John Hart Ely to Constitutional Theory*, 89 YALE L.J. 1037 (1980).

This standard would not apply to the Nebraska statute invalidated in *Sporhase*, but might apply to coal slurry bans. In the second case, especially where energy policy is at issue, state decisions are likely to command a prominent place on both the local and national political agenda, and the possibility of political relief is a real, rather than a theoretical, possibility. The danger of politicizing water law still exists, but legislatures retain a marginal comparative advantage over courts to do inter-regional equity, if that is required. Because of the potential for abuse, the state ought to carry the burden of explaining the purpose of its statute and of demonstrating the likelihood of effective non-judicial relief.[121]

H. Conclusion

This article has suggested a major revision in the Supreme Court's use of the negative commerce clause in order to protect the flexibility of the western states to allocate their water resources. Perhaps my arguments can be dismissed as special pleading, but they are grounded in a deep respect for the positive role that western water law has long played in shaping the development of the region. To allow the states to continue to play this role, courts need to avoid formulating too many hard and fast rules about the duty to share scarce waters among interested states. Existing principles of law provide a sufficient context for the political process to function to determine inter-regional equity issues. While the courts may be the proper forum for deciding questions relating to train lengths, mudguard standards, and apple labelling, the political process is, in my opinion, the superior mechanism, though perhaps only marginally so, for resolving inter-regional equity debates over water allocation.

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[120] *But see* Stewart, *Interstate Resource Conflicts: The Role of the Federal Courts*, 6 HARV. ENVTL. L. REV. 241, 248 (1982). Professor Stewart observes:

> The judicial ban on discriminatory state taxes and regulations, like the per se rule against price fixing, has the virtue of simplicity. There are few instances where discriminatory state measures accomplish anything beyond transferring wealth from one state to another, and the effort to identify the exceptions to the rule is likely to cost more than it is worth.

(footnote omitted).

[121] The challenger bears the burden of presenting a prima facie case which includes a showing of disproportionate impact, but a court can best avoid the dangerous plunge into the motives by shifting the burden of justifying the statute to the state. Eule, *supra* note 75, at 471.

DECISION:
A Bulletin on Natural Resource Conflicts in the West

WESTERN NETWORK

Competition for Southwestern Water Is Changing Water Law and Management Strategies

Western Network will publish this summer the third volume in its **Water in the West** series, entitled **Western Water Flows to the Cities**. This sourcebook surveys disputes in seven southwestern states that stem from the effort to satisfy the water demand of rapidly growing cities. In this bulletin, we summarize three of the cases to be covered in that volume in order to highlight some of the new approaches to water law and management that are developing in response to competition over scarce water resources. El Paso's effort to secure access to New Mexico groundwater has prompted the latter to rewrite some of its groundwater appropriation laws and to study several new approaches to conserving water for in-state use. Los Angeles' long-standing conflict with residents of the Owens Valley about groundwater pumping has led to a new attempt at a negotiated groundwater management strategy. And the effort of the Department of the Interior in southern Arizona to find a secure water source to satisfy a congressionally enacted water rights settlement on behalf of the Ak-Chin Indian Community has led to conflict with the City of Yuma. The outcomes of these disputes may well modify the basis for decision-making about several aspects of water management and are also of great interest to understanding new approaches to dispute resolution relating to this region's most contested resource.

Los Angeles and the Owens Valley: A New Chapter

Conflict over water between residents of the Owens Valley in Inyo County and the City of Los Angeles began in the early part of this century and continues now, as the city pumps Owens Valley groundwater to meet its urban water demands. The most recent phase of this conflict has involved the parties in lengthy litigation which has lasted over a decade. To resolve the court cases, Los Angeles and Inyo County have stipulated that they will work on a joint groundwater management plan, which, if approved, will fund studies of the environmental effects of continued, extensive pumping; provide for the annual pumping rate to be determined jointly by the county and city and will reduce the expense of water delivery for many valley residents. The agreement is the subject of heated controversy in Inyo County.

It was in 1913 that surface water began to flow through an aqueduct built to carry water 250 miles to Los Angeles from the Owens Valley. Flanked on the west by the Sierra Nevadas and on the east by the Inyo-White mountains, this narrow, high desert valley runs north-south for 100 miles. Although the valley has an average annual rainfall of a scant 4 to 6 inches, relatively large amounts of water flow to the valley floor from the surrounding mountains, accumulating in a shallow aquifer which supports a flora that could not survive on rainfall alone. More than 90% of Inyo County residents live in the Owens Valley and depend on tourism, agriculture, recreation and governmental operations for their livelihood. In 1905, in order to gain control over water rights in the watershed, Los Angeles filed in Inyo County for water rights to the Owens River. Later that year, Los Angeles voters approved a bond issue of $1.5 million to purchase Owens Valley land and rights of way. By 1920, the city owned the bulk of private land and water rights in the valley. Some valley residents were dissatisfied with land values set by appraisors hired by the city, and violence erupted when a group of valley residents organized to secure higher prices for their land and water—the aqueduct was blown up several times and the main diversion works was seized by a group of angry ranchers. But Los Angeles soon became the principal landholder and taxpayer in Inyo County, controlling more than 300,000 acres and the accompanying water rights.

The Los Angeles Department of Water and Power (LADWP) began to pump groundwater from the Owens Valley aquifer to the city through a second aqueduct in 1970, increasing the potential to carry water from the valley by 50%. In 1970 the state legislature passed the California Environmental Quality Act (CEQA) requiring state agencies to prepare an environmental impact report (EIR) on any proposed project which might produce a significant environmental effect, which could include groundwater pumping.

According to Inyo County Water Department's **Owens Valley Water Management Plan and Summary of Impacts**, Owens Valley residents soon observed several environmental changes which they attributed to groundwater pumping: drought-killed vegetation and a resulting increase in winter dust storms as dying plants exposed erodible desert soils, as well as the disappearance of several springs, seeps and artesian wells. An increase in airborne dust which caused respiratory problems for many older residents of the valley was also attributed by this report to the effects of pumping.

(continued)

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Inyo County filed a suit known as **Inyo I** in 1972 against Los Angeles for the city's failure to file an EIR on the impact of increased groundwater pumping on the Owens Valley. The court of appeals ruled that increased pumping by the city was subject to the CEQA, ordered Los Angeles to file an EIR and imposed a temporary ceiling on the extraction rate of pumping of 89 cubic feet per second(cfs), which was doubled when Los Angeles appealed in superior court. A series of lawsuits, **Inyo II, III, and IV,** followed as the county challenged the city's EIRs and objected to court-set levels of groundwater pumping.

In 1976 and 1977, as Los Angeles and Inyo County battled for groundwater in the state courts, California experienced a drought of unprecedented severity, and the governor established a commission to review water rights law. Although the state had a complex system for the allocation of surface water, there was no legislation specifically governing groundwater. The commission submitted its final report in 1978 and recommended that the state take an active role in managing groundwater. Legislation to implement the commission's recommendations was introduced in both houses of the state legislature but died in committee.

Throughout the period of litigation, Inyo County and Los Angeles made attempts to work out a joint groundwater management plan. When no agreement was reached and the legislature failed to enact groundwater legislation, the Inyo County Board of Supervisors proposed an ordinance and placed it before the voters in a referendum. The ordinance, adopted by a margin of three to one, created a county water department to prepare a water management plan and required registration of wells and the submission of an application for permit to extract groundwater. Los Angeles challenged the ordinance on both substantive and procedural grounds; the superior court found it unconstitutional, and the county was directed to prepare an EIR on the implementation of the ordinance. Many of the recommended enhancements and mitigative measures proposed by the county in its plan were incorporated into the joint management agreement.

Inyo County and Los Angeles together have drafted stipulations and submitted for court approval a joint management plan for Owens Valley groundwater, which would stay the litigation for the period of the agreement. As it now stands, the five-year agreement (with early termination allowable) seeks to resolve differences between the parties through the following main provisions:

1. Knowledge gained from United States Geological Survey (U.S.G.S.) groundwater and vegetation studies will be used to develop a long-term, cooperative, groundwater management plan. Los Angeles will annually pay a share of the cost of the studies to the county.
2. If a long-term plan is adopted, it must follow CEQA procedures.
3. Both parties would stay all pending litigation and initiate no new lawsuits.
4. Los Angeles will also lease water services to Lone Pine, Laws and Independence, three towns in Inyo County, for the term of the agreement at a rate set by the county which is fifty percent lower than their citizens have been paying as individual customers of LADWP; the parties will meet to attempt a lease purchase of their water systems. Residents of Big Pine will also be given the opportunity to reduce their water rates by a similar amount.
5. Each year, Los Angeles and Inyo County would attempt to set a groundwater pumping rate. If the county and city fail to agree on an annual pumping program, then Los Angeles is allowed to pump the amount set forth in a pumping table based on the percentage of average annual runoff to Owens Valley. The pumping limit is now 149.56 cfs, but the pumping table would allow Los Angeles to pump as much as 210 cfs in a dry year, including in-Valley uses.
6. Measures to mitigate and enhance environmental changes resulting from groundwater pumping by LADWP will be carried out at the city's expense.
7. If the pumping table is used, Inyo County may break the agreement on one year's notice, if it is determined by the county that such action is necessary to protect the environment of the Owens Valley.
8. If the city uses the pumping table, Los Angeles must make reasonable increased use of alternative water sources such as their share of the Metropolitan Water District and the Los Angeles groundwater basins and take reasonable conservation measures.

In two day of public hearings at which the county board of supervisors presented the stipulations, representatives of the California Native Plant Society, the Audubon Society, the League of Women Voters, the Sierra Club, and the Owens Valley Committee, a local citizens' group organized to protest certain provisions of the agreement, opposed the pumping levels specified in the table. Others testified on behalf of conciliation between Los Angeles and Inyo County as proposed in the agreement and welcomed an end to the long-standing litigation.

The Inyo County Board of Supervisors voted unanimously on March 27, 1984, to accept the agreement, as described above. It was approved by the LADWP Board of Commissioners on April 5, 1984, and by the Los Angeles City Council on April 18, 1984. Finally, all three courts in which there are cases still pending between the county and Los Angeles must approve the stipulation documents which apply to the cases under their jurisdiction before the agreement can go into effect.

If Los Angeles goes to the pumping table, the agreement could be broken. The Owens Valley committee filed suit in Inyo County Superior Court in opposition to the agreement, and their motion was denied. They have since filed an amicus brief in the Third District Court of Appeals in Sacramento.

Western Network is a non-profit organization providing objective information to the public about natural resource conflict in the western states. Through programs of research, information dissemination and policy dialogue, it seeks to identify causes of conflict about resource use and create opportunities for new institutional and management strategies that may result in more stable decision-making about the region's natural resources. **Western Network** is funded entirely by private foundation grants and income from the sale of its publications.

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Excerpts from Official Summary of City of

- **Term**

The term of the agreement is five years, subject to an option by the County to sooner terminate the agreement in specific circumstances on one year's notice. The term may be extended by the parties if additional time is required to complete the studies or the long-term management plan.

- **Purpose**

The parties seek to resolve their differences through cooperation rather than litigation by using knowledge gained from certain groundwater and vegetation studies (which are being conducted by the U.S.G.S. and the parties) to attempt to jointly develop and adopt a long-term cooperative groundwater management plan for the Owens Valley. During the term of the agreement, certain lawsuits between the parties are placed "on hold" to allow the studies to proceed in the absence of active litigation, and the parties will manage groundwater extractions and implement enhancement/mitigation projects in the Owens Valley with the goal of enhancing the Valley's environment and of avoiding or minimizing any adverse impacts of groundwater extractions while assuring an adequate supply of water for both Los Angeles and the Valley.

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Omitted sections cover effects of the agreement on pending litigation, existing studies and agreements, and financial arrangements between the City and County. Other sections assert that there will be no effect on existing water rights and commit both parties not to take action which would affect the agreement.

- **Annual Pumping Program—Joint Management**
  Agreed Upon Annual Pumping Program

During the term of the agreement, the Standing Committee, considering certain guidelines annually will develop a pumping program for each runoff year (April 1 to March 31). To assist the Standing Committee, the Technical Group will make written recommendations concerning the program.

Failure to Agree Upon an Annual Pumping Program—Maximum Pumping

If the Standing Committee has not established an annual pumping program by May 15th of any year, then the City must comply with certain principles which are protective of the Owens Valley and which require the use of water from other sources, and may not pump from the Valley in excess of amounts set forth on a table which is based on the percentage of normal annual runoff to the Valley. The maximum amount of pumping allowed by the table (including 50,000 acre feet which can only be "used" for in-Valley uses) ranges from 106,000 (146.4 c.f.s.) in a runoff year with 100 percent or above runoff, to 210,000 acre feet (290 c.f.s.) in a drought year with 60 percent or less runoff. Water "used" for new enhancement/mitigation projects which have been approved by the Standing Committee is over and above the amounts set forth on the table. "Use" of water for new enhancement/mitigation and in-Valley uses does not include water which returns to the City's aqueduct system and is exported from the Valley.

In the event that the pumping table is employed, the County may terminate the agreement effective June 1st of the next calendar year if it is determined by the County that such action is necessary to protect the environment of the Owens Valley. Further, the pumping table is only for the purpose of compromise and may not be used in litigation or in an administrative proceeding by either party without the prior written consent of the other party.

Failure to Agree Upon an Annual Pumping Program—Prevailing Principles

If the provisions of the pumping table are in effect, for that runoff year, the City must:

New Mexico, *Sporhase* and El Paso

Most western states, often through their constitutions, declared water resources to be public property and reserved to the state administration the power to confer rights to use water on private citizens. This concept of state ownership of water and a concomitant conviction that water was to be treated differently from other resources led to the drafting of statutes that attempted to limit access by out-of-state citizens to water within each state's boundaries. The "public" to be served by state government in the administration of water, in other words, consisted primarily of the citizens of that state. Several laws have forbidden the exportation of water across state lines or have removed from the list of beneficial uses certain water projects, like coal slurry pipelines, or have required that water might be exported only to a state that permitted a reciprocal exportation.

In 1982, the Supreme Court declared one of these state statutes to be unconstitutional. In the case known as **Sporhase v. Nebraska**, the court attacked the longstanding concept of public ownership of water and concluded, with certain qualifications, that water should be treated like a "good" sold in interstate commerce. The court also acknowledged that arid states need to conserve water for the future, indicating that federal legislation authorizing states to maintain groundwater stocks within their borders would be an acceptable measure to guard against future water shortages. It suggested that specific state policy objectives relating to public health as well as conservation might well justify restrictions on out-of-state appropriations but concluded that arbitrary restrictions not tied to such objectives would be unconstitutional. The western states then began the process of revising their water laws to comply with guidelines provided by this decision.

While this decision was being formulated, the City of El Paso was in the midst of its efforts to obtain groundwater pumping permits from New Mexico for waters located in two aquifers in the Mesilla valley near Las Cruces. When the state engineer denied El Paso's application, following a state law forbidding such out-of-state appropriations, the city sued, and the federal district court for New Mexico held in early 1983 that New Mexico's statute was unconstitutional under the guidelines set forth in the Sporhase decision. The court concluded, "So drastic and burdensome a measure as a total ban on interstate commerce in groundwater can only be justified if it is narrowly tailored to times and places of shortage." City of El Paso v. Reynolds, 563 F.Supp. 379, 391 U.S.D.C.N.M. (1983) Following this decision, New Mexico revised its law regarding out-of-state appropriators. This prompted the Tenth Circuit Court of Appeals later in the year to vacate the original judgment and to require a new trial on El Paso's contention that the revised law still imposes an impermissible burden on interstate commerce.

More narrowly written than the first, the language of the new law provides a more distinct policy basis for tightly controlling water export by emphasizing the state's water management goals

Los Angeles/County of Inyo Stipulated Agreement

(1) Maintain all in-Valley uses of water subject to reasonable conservation.

(2) Increase, to the extent reasonably practical, use of water from the Metropolitan Water District and from certain Los Angeles groundwater basins. This means, subject to physical availability, the use of no less that the total annual amount of water from the MWD and Los Angeles groundwater basins customarily used in a runoff year since 1970 with water supply circumstances most similar to the year in question, and increased use of such water above this minimum subject to listed criteria.

(3) Increase, to the extent reasonably practical, the conservation of water by users in Los Angeles and the Owens Valley. This means no less than past conservation efforts implemented in a runoff year since 1970 with water supply circumstances most similar to the year in question. Additionally, existing conservation ordinances and programs are to remain in effect and new increasingly stringent programs are to be implemented in response to decreasing annual estimated runoff to the Valley.

(4) Not increase groundwater pumping, even if allowed by the table, as a result of of any restriction which may be later imposed on the City's export from the Mono Basin.

(5) Implement (with Standing Committee approval) enhanceement/mitigation projects to avoid or minimize any adverse impacts of groundwater extractions by the City.

(6) Submit written monthly reports to the County concerning the City's actual use of water from the MWD and the Los Angeles groundwater basins, its conservation efforts, its use of surface and groundwater from the Valley and surface water from the Mono Basin and any proposed mitigation projects.

• • •

Omitted sections address a variety of enhancement and mitigation measures.

- **Emergencies**

Pumping in excess of the annual amount agreed upon, or in excess of the amount set by the pumping table, may be commenced immediately if such pumping is necessary to protect life, health, property, or essential public services. In such event, a report must be filed with the County within 24 hours and pumping limits will be modified accordingly by the Standing Committee.

- **Dispute Resolution**

Disputes between the parties will first be referred to the Technical Group and/or to the Standing Committee. In the event that one or the other of these committees are unable to resolve the dispute, the matter, except a claim of total repudiation of the agreement, may be submitted pursuant to simplified and expedited procedures for resolution to the Superior Court Judge then assigned to the "Ordinance" case. (Claims of total repudiation of the agreement may be submitted directly to the Court of Appeal which has jurisdiction over the "EIR" case.) The decision of the Superior Court Judge on a disputed matter is binding on the parties.

• • •

Omitted sections concern the termination of tax litigation brought against the County by the City and indicate that the agreement consists of three separate legal documents, each called a stipulation and order, which will be lodged with three separate courts.

—April 9, 1984

of conservation and the protection of the health and welfare of its citizens. It does permit appropriations by out-of-state applicants but requires the state engineer first to see if the requested water could be used to offset shortages anywhere in the state. The new law also empowers the state engineer's office to set standards for water use in another state. Outlining procedures for application to withdraw and transport waters for use outside the state, the statute says:

> "The state engineer shall consider. . .whether there are water shortages within the state of New Mexico and whether the water that is the subject of the application could feasibly be transported to alleviate water shortages in the state. . .The state engineer is empowered to condition the permit to insure that the use of water in another state is subject to the same regulations and restrictions that may be imposed upon water use in the state of New Mexico. . ."
>
> [Laws 1983, Senate Bill 295, Section 1, D (4) and F]

This law is only one aspect of New Mexico's effort to find a new legal basis for retaining control over in-state waters. In a 1983 study of the impact of recent court decisions concerning water and interstate commerce on water resources of the state, the Water Law Study Committee, created by the state legislature, recommended that the state: (1) seek congressional legislation permitting limitations on interstate transfers under state law; (2) initiate compact negotiations with Texas concerning surface and related groundwater in the area of the Rio Grande Basin affected by El Paso's application; (3) put in place a stay on state permits for new appropriations in the southern New Mexico groundwater basins; and (4) authorize a study of the possibility of state appropriation of water rights and distribution of water within its borders. If neither a federal solution nor an interstate compact could be obtained, the state should be ready, as a last resort, in the view of the committee to appropriate and lease sufficient water supplies for future in-state needs. The state could simply decline to sell if it felt any out-of-state offer to buy water would endanger in-state uses.

The 1984 session of the New Mexico Legislature authorized both the stay on new groundwater permits and the study of state appropriation. The state thus finds itself in a position similar to that Montana faced in the early 1970's when applications for water rights for energy projects in the Yellowstone Basin prompted that state to impose a moratorium on new appropriations. The state then adopted a reservation system which set aside water for future use by public entities, including irrigation districts, before permitting new allocations to such private users as energy companies. New Mexico is in the analogous position of trying to protect the future interests of in-state constituencies before permitting water to be allocated by an inter-state market. The approach it takes in the coming year could have a marked effect on the basis for decision-making about groundwater throughout the state. Other states, though not so hard pressed as New Mexico by an out-of-state water demand, will study its actions carefully as they deal with the basic problem of how to relate the needs of in-state water users to the pressures of an interstate market.

Recently, the state has drafted a bill to seek a congressional resolution of the problem. With the agreement of the governor, the attorney general, the state engineer and the congressional delegation, a bill may soon be introduced that could ban the interstate appropriation of water unless it is done in accordance with: 1) an interstate compact, 2) a judicial equitable apportionment, 3) an act of Congress, or 4) approval of the exporting state. Such a bill would, in the eyes of its sponsors, satisfy some of the structures of the Supreme Court's Sporhase decision and ensure that western states retain authority over the interstate movement of water.

Clarification: The last issue of **Decision** contained a brief article describing the formation of the Hydrology Task Force by New Mexico's Energy and Minerals Department. **Western Network** summarized in that article the concerns that some groups have expressed about the impacts of energy development on groundwater of the San Juan Basin. We regret if the editing of the piece suggested either that **Western Network** was asserting its own views on the hydrologic effects of coal mining in the San Juan Basin or that coal mining alone was responsbile for the impacts mentioned. **Western Network** does not take policy positions on the substantive issues involved in the disputes we report.

Finding Water for the Ak-Chin Indian Community

In a 1978 Water Settlement Act, the Ak-Chin Indian Community became one of the first tribes to sign a "water treaty" with the United States government. In this act, the federal government committed to provide the Indian community with a permanent supply of water, yet did not specify from where that water would come, how it would be delivered or other physical details of the plan. By providing for a water supply to replace the depleted groundwater resources of the community, the 1978 act elininated a source of conflict over water rights between Indian and non-Indians in central Arizona. But when it proved difficult to find a water source to meet the terms of this settlement, the Department of the Interior asserted the secretary's authority over water supply contracts issued to cities and irrigation districts in the lower Colorado River region. It has proposed breaking certain contracts for permanent water delivery which have not been put to full use in order to free up as much as 100,000 acre-feet of water annually. This proposed action has met with resistance from the state as well as the affected municipalities and irrigation districts.

Ak-Chin is a small community with a 21,840-acre reservation south of Phoenix. Successfully farming cotton, wheat, barley and maize, they became one of the few Indian communities to have come close to economic self-sufficiency on their reservation. Surrounded on all four sides by non-Indian farming, they have been pumping groundwater from increasingly greater depths until the cost of electricity to run the pumps has forced them to retire all but 4,000 acres.

In 1978, Congress enacted legislation under which the Department of the Interior would deliver 85,000 acre-feet per year of permanent water to the Ak-Chin, or pay replacement costs. A temporary supply from a federal well field in the Vekol Valley was to be delivered by January 1, 1984, and a permanent one was promised by 2003.

After assessment of the Vekol Valley aquifer system, Interior determined that this groundwater source had far less capacity than originally estimated and that pumping it would mine groundwater to which the nearby Papago tribe had rights. The department proposed to the Ak-Chin a renegotiated agreement under which Ak-Chin agreed to reduce their annual amount to 75,000 acre-feet in normal years, 72,000 acre-feet in a drought year and 85,000 acre-feet in years the community requests it and the surplus is available; and the U.S. would pay all delivery costs and would move forward the deadline for a permanent supply to 1988. In the Agreement in Principle, signed and dated September 23, 1983, the Ak-Chin consented to the smaller total amount and agreed not to sue for breach of contract. As further compensation, Interior agreed to pay operation and maintenance costs on all Ak-Chin wells until the permanent supply is in place, provide $50 million in economic development loans and grants and write off some smaller loans.

Even with this revised agreement, Interior has had difficulty identifying another source of permanent water supply. The community has an allocation of 58,300 acre-feet from the Central Arizona Project (CAP). But it is subject to reduction in years of shortage and under those circumstances would provide a firm yield of no more than 20,000 acre-feet annually. The problem is thus to find a secure supply of an additional 55,000 acre-feet to meet the terms of the revised Ak-Chin water service agreement. Interior could find no alternative groundwater sources, but in examining the federal contracts for water from the lower Colorado River, they discovered that the cities of Kingman and Yuma, Arizona, and the Yuma Mesa Irrigation and Drainage District had contracted for more water than they were actually using. According to Interior, the irrigation district has proposed deferring use of its unused water for 40 years to allow marketing it to the salinity control program or the Central Arizona Project.

Interior is now building a case to reallocate for use by Ak-Chin a portion of this unused but contracted water, which it has termed "undeveloped surface water." This supply is not to be counted as part of the CAP project but instead is water allocated by the secretary under authority of the Boulder Canyon Project Act. Kingman, Yuma and the irrigation district as well as the State of Arizona are protesting this breaking of what they view as binding contracts. Interior says that a contract for water with them should be considered an application for a water right, which is not perfected until the water is put to beneficial use, or due diligence shown; and it cites the 1902 Reclamation Law's "use it or lose it" clause which states that "Beneficial use shall be the basis, measure and limit of the right. . .[to the contracted water]" as well as Arizona's own water rights statute which reflects the concept of beneficial use, as the basis for this claim. The lower Colorado is managed differently from any other river due in part to the language of the Boulder Canyon Project Act of 1928 wherein the water is not allocated through the state but directly by the Secretary of the Interior, who has "the general authority to make contracts normally [including] the power to choose with whom and upon what terms the contracts will be made." Arizona v. California, 373 U.S. 546, 83 S.Ct. 1468 (1963) The secretary maintains that he is free to reallocate the water as he sees fit, considering other more urgent needs or legislative mandates.

The City of Yuma feels it should not be punished for controlling growth and implementing conservation measures by forfeiting a part of its allocation. They say that Yuma was far sighted in nailing down a water supply for its future needs, and now its citizens are being asked to sacrifice what they had planned for. With its recent pro-growth policy, Yuma claims it may need all 50,000 acre-feet to which it is entitled under the disputed contract. It thinks that Interior should buy water rights on the market as other groups have had to do.

The Ak-Chin and the United States find themselves bound together in a difficult situation with few alternatives. The Indians contracted for water, not money, and because their community relies upon agriculture for cultural as well as economic sustenance, they believe its existence would be jeopardized if the water allocation is not delivered. The Reagan administration has promoted negotiation as the preferred way of settling Indian claims to water and is eager to have this first settlement viewed in a favorable light by other tribes. The Ak-Chin have been accommodating but may very well file suit if Interior fails to keep its latest promises.

High Plains, low water

ONE OF THE PREMIER U.S. grain-producing regions—the area watered by pumping from the enormous Ogallala aquifer—is depleting its groundwater. This threat to agriculture, plus the depletion of the area's major petroleum resources, prompted a study of associated potential economic, social, and environmental changes—the *Six-State High Plains–Ogallala Aquifer Regional Resources Study*.[1] For understandable reasons, it commonly is referred to as the High Plains Study.

High Plains history

As the frontier was pushed westward in the nineteenth century, the High Plains was the pathway to the undeveloped West. As time passed, three major technological developments—barbed wire, windmills, and the repeating handgun—permitted settlement of the High Plains and a ranching and farming culture began to develop. Settlement and agriculture flourished—for a while: unusually propitious moisture conditions during the 1880s produced bumper crops from the fertile soil, and many farmers moved in from the East. When more usual rainfall conditions returned in the succeeding decades, many farms and settlements were ruined.

In the late nineteenth century, A. M. Simons wrote in the *American Farmer*: "From the 98th meridian west to the Rocky Mountains there is a stretch of country whose history is filled with more tragedy and whose future is pregnant with greater promise than perhaps any other equal expanse of territory within the confines of the Western Hemisphere."[2] As implied, the region was characterized by periods of boom and bust. The nadir came in the 1930s, when drought coincided with the Great Depression. This is the time when the term "Okies" was coined to characterize those economically displaced from the plains—unwilling, tragic vagabonds, searching for opportunity elsewhere, mainly in California.

But the late 1930s saw other technological developments of great portent for the future: improved well-drilling equipment, advanced pumping technology, and cheap energy opened the area to large-scale irrigation from deep wells and permitted tapping of the Ogallala, regarded at the time as a "vast underground river"

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[1] High Plains Associates, *Six-State High Plains–Ogallala Aquifer Regional Resources Study*, A Report to the U.S. Department of Commerce and the High Plains Council (Austin, Texas, March 1982).

[2] *High Plains Study*, p. xxxv.

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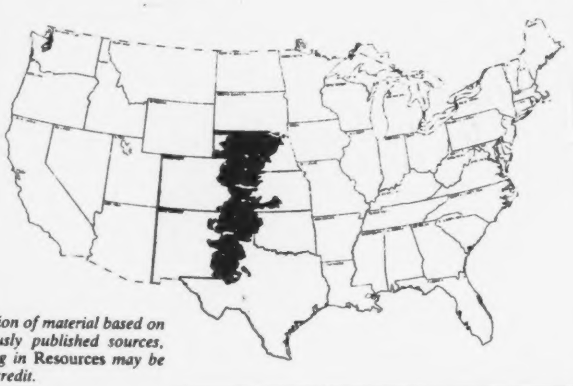

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Figure 1. The High Plains Region–Ogallala Aquifer. *Source:* **High Plains Associates,** ***Six-State High Plains–Ogallala Aquifer Regional Resources Study*****, A Report to the U.S. Department of Commerce and the High Plains Study Council, March 1982.**

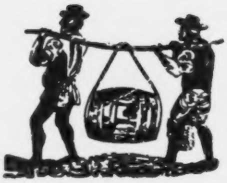
and an "inexhaustible resource." The demands of World War II stilled development of the underground water resource, but soon massive development took place, initially in the southern part of the aquifer.

Some 15 million acres of land now are watered from the Ogallala. Development on such a scale soon revealed not an inexhaustible resource, but a depleting one. By the 1970s some areas were falling into decline, especially in Texas, where the earliest development occurred. At the same time and in some of the same areas, oil and gas production also was falling off. In the northerly parts of the aquifer, especially in Colorado, Kansas, and Nebraska, where the aquifer lies deeper under the surface, development came later and has continued. Also, in contrast with the situation in the south, parts of the northern aquifer receive significant recharge from the surface.

Nevertheless, at the behest of the states, principally Texas, Congress in 1976 passed section 3 of Public Law 94-586. It provided for a comprehensive survey of alternatives for the region, including the possible importation of supplemental water—a dream with a long history in Texas. (In the 1960s, a scheme to import 10 million acre-feet per year from the Mississippi failed twice in public referendum.)

The mandated study, begun in 1978, was carried out by Camp Dresser and McKee in joint venture with Arthur D. Little as prime contractor, and with Black and Veatch as subcontractor. In addition, each of the states and the U.S. Army Corps of Engineers were involved. I was the principal economics consultant to the prime contractors and participated actively in all stages of the detailed design and execution of the study.

Before discussing the study and its results, it may be useful to say a little more about the Ogallala and its development. This huge area of about 220,000 square miles is the unconsolidated remnant of large deposits of gravel, sand, and silt eroded from the Rockies over the eons. Much of the water in the aquifer is fossil water, especially, as noted, in the southern portions. Development in recent decades has been both rapid and on an extremely large scale: in 1950 about 7 million acre-feet of water were pumped to irrigate some 3.5 million acres and by 1980, about 21 million acre-feet were used to water roughly 15 million acres. About 40 percent of the nation's fed beef is supported by grain grown on the High Plains. A complex regional infrastructure has developed based on this agricultural development and, in some cases, also on oil and gas, and such substantial cities as Lubbock and Amarillo have grown up.



Management strategies

To project how irrigated agriculture might evolve, the High Plains Study examined several plausible management strategies and compared them to a baseline projection that assumed gradual spreading of best irrigation practice but no new policies. The management strategies used in the analysis are:

1. Stimulate voluntary conservation practice using education, research, demonstration, and economic incentives.
2. Add some regulatory programs.
3. Augment local water supply by cloud seeding, groundwater recharge, and the like.
4. Transfer surface water from basin to basin within a state.
5. Allow interbasin transfers from outside a state.

Numbers 1 and 5, in my judgment, are the most interesting. Given the history and traditions of the area plus the costliness of some of the other alternatives, number 1 is notable because it seems to me most likely to happen. And 5 is interesting because it takes a hard look at the dream of imported water so long cherished by some interests on the High Plains.

I will spare the reader details of the fairly complicated models (mostly linear programming and input–output) used to project results of the strategies to 2020 except to note that they depend critically on assumptions about continuing growth in yields and the adoption of conservation practices. Also, because pump lifts make High Plains agriculture very energy intensive, water conservation may be driven fully as much by energy costs as by the perception of limited water supplies.

Number 1 results. For management strategy 1, every economic indicator is higher (in constant dollars) for 2020 than it is for 1977 (the base year). This is true for both the north (Nebraska, Kansas, Colorado) and the south (Oklahoma, New Mexico, Texas), and for each state the total value of agricultural products for the region as a whole would be up 3.3 percent and employment would increase by 1.1 percent. Under each nonimport strategy some land would go out of cultivation in both the north and the south, but overall this would be more than balanced by the development of new land. However, usable water remaining in storage in the south will be severely depleted by 2020.

The central, interesting, and—given the atmosphere of impending doom when the study was launched—surprising conclusion of the High Plains Study is that the economy based on irrigation from the Ogallala can continue to grow for many years in each state in the area. If these projections are valid, the adjustment to depleting supplies can be gradual and noncatastrophic.

Number 5 results. Let us turn now to a brief consideration of the importation alternative. Under management strategy 5, the objective for purposes of study is to bring enough supplemental water to replace land that would go out of irrigation under management strategy 1. Possible routes that are feasible from an engineering point of view are shown in figure 2. Under this alternative, 4.1 million acre-feet of imported water is brought yearly to terminal storage for use on the High Plains; total water use in 2020 is projected to be 25.4 million acre-feet, about 20 percent above management strategy 1. Since pumping from the aquifer is not reduced under this strategy, the amount of water remaining in storage is unaffected.

Even a cursory look at the economics of imported water starkly reveals what an outlandish idea it is. Based on projected returns to land and water, the absolute maximum ability to pay for imported water would be around $120 per acre-foot.[3] The Army Corps of Engineers, which is unlikely to exaggerate the costs of the project, calculates that the cost of imported water would be $320 to $880 per acre-foot at projected energy prices.[4] But that is just the cost to bring water to a terminal storage reservoir on the High Plains and does not include distribution costs. I do not know what those costs would be, but it does not stretch belief to think that, given the enormous size of the region, average delivered water might cost again as much as terminal storage water.

If the actual willingness to pay, rather than the maximum possible, is, say, $75 per acre-foot (which is probably generous) and the cost of delivered water ranges around $1,000 per acre-foot, the cost would

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[3] *High Plains Study*, pp. 6–87.

[4] *High Plains Study*, pp. 6–77.

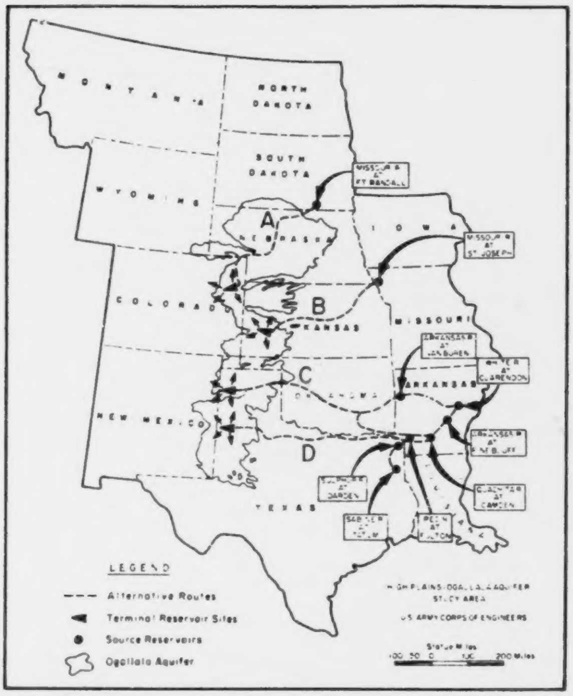

Figure 2. Management Strategy 5: Interstate water transfer route alternatives assessed by the U.S. Army Corps of Engineers. *Source*: Adapted from figure 5, review draft, "Water Transfer Elements of High Plains–Ogallala Aquifer Study," January 1982.

exceed willingness to pay by more than an order of magnitude.

Why would regional interests support what appears to be such an economic disaster—a project whose costs vastly exceed their ability to pay for it? The answer is that they do not expect to pay for it, or at least not much, and the history of distributional politics concerning western water bolsters this expectation. History notwithstanding, however, it seems doubtful that a big enough legislative "Christmas tree" could be put together to support major importation of water to the High Plains. In my judgment, political, economic, and ecological considerations make the future transfer of such huge amounts of water all but impossible.

Conclusions

First, the Ogallala aquifer indeed is depleting, but there is no water crisis on the High Plains. And second, water importation is a thoroughly bad idea, even if just the economics are considered; imagine an environmental impact statement for such a project. But dreams do not die: in its report, the Texas 2000 Commission's first recommendation about water is that a plan be developed with options for interstate and international transfers.[5]

This article is adapted from Allen V. Kneese's address in June to the Conference on the Future of the American Granary: Adjusting to Change in an International Setting, held in Saint Paul, Minnesota. Kneese is a senior fellow in RFF's Quality of the Environment Division.

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[5] The Cross Section, April 1982, p. 4.

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Day of Reckoning for the Garrison Project

New commission to have last word on troubled North Dakota irrigation plan that is widely viewed as a pork barrel classic

JAMESTOWN, N.D.—This year could mark a turning point for the Garrison Diversion Unit, a vast, problem-ridden irrigation project in North Dakota that environmentalists have been trying to kill for the past dozen years.

“The Interior Department, at the behest of Congress, has appointed a 12-member commission headed by former Louisiana governor David C. Treen to decide the fate of the project, including a possible alternative plan, by 31 December.” Work is to stop at the end of this fiscal year, 1 October, and a fiscal 1985 appropriation of $53.6 million will be held up until January. “But unless two-thirds of the commission agree to halt or modify the project, it will proceed as planned.”

The Audubon Society, which has taken the lead in battling Garrison, negotiated the new arrangement with Senator Mark Andrews (R–N.D.) in the face of a very tight appropriations vote in the Senate. The estimated costs of the project have grown from $207 million in 1965 to $1.2 billion. But it has been kept alive through the determined efforts of North Dakota politicians, including Andrews and Senator Quentin Burdick (D–N.D.), who are both powerfully situated on the Senate Appropriations Committee.

The commission, composed mostly of western Republicans, including several scientists and environmentalists, has a tremendous task before it. The Garrison project has roots extending back into the Depression and involves major questions relating to Western water allocation, the economics of reclamation and irrigation, wildlife and land conservation, and international environmental responsibilities.

North Dakota has long wanted to find a way to harness the abundant flows of the Missouri River. Following the dust-bowl days of the 1930's the Army Corps of Engineers and the Interior Department's Bureau of Reclamation put together a water scheme, known as the Pick-Sloan plan, which became the Flood Control Act passed by Congress in 1944.

The Corps' role was to build six dams on the Missouri, providing flood control and navigation in a ten-state area. One of these was the Garrison Dam in North Dakota, which was completed in 1953 and entailed the flooding of a half-million acres of land. The Bureau of Reclamation was then to divert some of this water for the state's use.

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The original idea was to supply water for a million acres in the dry western part of the state. But soils there were found to be too dense for irrigation, so new target lands were designated in the central and eastern regions. Finally, in 1965, Congress authorized a scaled-down plan to irrigate 250,000 acres.

The project is a system of canals and reservoirs extending through a 25-county area, fed by Missouri water pumped from Lake Sakakawea created by the Garrison dam. Ironically, the project now reaches through some of the wettest land in North Dakota—its prairie pothole country, a system of sloughs and marshes created 10,000 years ago by glaciers, that supply nesting and migration habitat for several hundred thousand waterfowl a year.

The bulk of the network is in the Hudson Bay watershed, whose boundary cuts diagonally across the state. This means that much irrigation runoff could eventually make its way to Canada.

Construction on the first major project feature, the 74-mile long McClusky Canal, began in 1970. It did not take long for the troubles to start. Farmers outraged by having their farms torn up for the canal started suing in 1972. The Council on Environmental Quality recommended suspension of the project in 1973. The Audubon Society in 1976 sued over the environmental impact statement (the first one, in 1974, was 11 pages long), and obtained a court order which halted construction for 5 years. The project made President Carter's water project "hit list," and it lost House support several years ago.

Meanwhile, during the 1970's the Canadian government was getting increasingly concerned at the prospect of pollution from irrigation as well as the possible transfer of undesirable aquatic species between two drainage basins that had been separate for 10,000 years. They feared that fish organisms, particularly rainbow smelt, would make their way through the McClusky Canal to the Lonetree Reservoir, a 25-mile long reservoir that is to be the heart of the project, and from thence into rivers flowing into Lakes Winnipeg and Manitoba. Remembering the lamprey, which got to the Great Lakes from the Erie Canal, they feared decimation of the lakes' commercial and sport fisheries.

The International Joint Commission, whose purpose is to monitor the U.S.-Canadian Boundary Waters Treaty of 1909, did a detailed 2-year study of the situation. It concluded in 1977 that anything less than 100 percent protection from interbasin transfer of biota would violate the treaty.

Things looked pretty grim for Garrison until the advent of the Reagan Administration and its secretary of Interior James Watt. Watt, far more enthusiastic about the project than his predecessor, Cecil Andrus (who had labelled it a "dog"), got things started again in 1981 by issuing assurances that the project would be limited to "Phase I," at least until all the problems were resolved, and that the Canadian watershed would remain inviolate.

It will take 8 to 10 years to complete Phase I. This phase is designed to irrigate only 85,000 acres, but it contains most of the basic features for the full project, except for a canal stretching northward to Canada's Souris River, which loops down into North Dakota. The Souris loop contains 103,000 acres of would-be irrigated land.

The Phase I designation has certain advantages for the project. Officials at the Garrison Diversion Conservancy District can defend its high costs (taken as a discrete entity, Phase I's per acre irrigation costs would exceed $8000) by maintaining it is the infrastructure for the larger project. Sensitive environmental and political questions about the entire project, however, can be deflected on the grounds that they are "premature."

Justification for the Garrison idea is usually expressed in sweeping statements about the state's development future and North Dakota's right to compensation for its "sacrifice" of prime farmland for the Garrison Dam. (Actually, 40 percent of the area was Indian reservation.)

Planners say irrigation is required to stabilize the economy—water would flow through the state "like blood flows through a living body" says a Bureau of Reclamation report—and that the project (with benefits to recreation and wildlife counted in) would boost the state's productivity by $200 million a year. The official benefit-cost ratio is 2.47:1; environmentalists say it is closer to 0.45:1.

North Dakota's chief crops are wheat, followed by corn and sunflowers. Irrigation would allow for expanded production of corn, as well as of alfalfa for feedlots and other, more high-priced commodities, say Garrison supporters. It will open the way for new processing plants, such as for corn oil.

Critics have pointed out that the government extensively subsidizes North Dakota farmers for not growing crops under the Payment in Kind (PIK) program. But this is dismissed by Garrison's attorney Murray Sagsveen as a "spurious argument" because PIK only applies to wheat and corn. Besides, he says, PIK is looking to the long-term future.

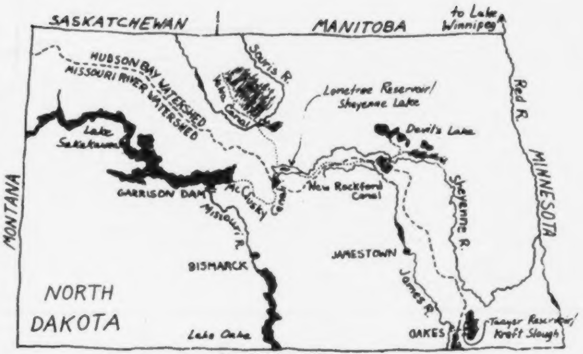
Further justification offered by project supporters is that North Dakota aquifers do not have very good water, and many towns are interested in getting a supply from the Missouri. But there is no official assessment of how the project matches up to North Dakota's water needs.

The high costs of the program are not a legitimate issue, the planners argue. Ninety percent of the project will pay for itself because users of power from the Garrison Dam—most of them out of state—will pick up 87 percent of the tab, and irrigators will pay 3 percent.

Critics of the Garrison project reject all these arguments. First of all, they claim that few farmers even want the project. (Spokesmen at the Conservancy District claim about 90 percent favor it, but acknowledge they haven't been doing any polling.)

In fact, many farmers have turned against the program. In a recent lawsuit, farmers in the Jamestown area tried to halt work because they anticipated flooding and pollution from irrigation runoff in the James River. Others are worried that leakage from the canals will pull salt up from the soils and damage adjacent crops. Still others have been riled by government purchases of wetlands for wildlife mitigation.

Nor are the benefits of irrigation evident to many farmers. Members of the Committee to Save North Dakota, made up mostly of small farmers, say would-be irrigators are put off by the costs: about $60,000 for a pump and center pivot to irrigate 160 acres—plus $25 or $30 per acre per year for operations and maintenance. Additional chemicals are also required.



Diversion plan: Irrigation areas for 250,000-acre plan are shaded. McClusky Canal is complete; Lonetree Reservoir, New Rockford Canal, and Oakes pumping plant under construction.

Corn, asserts Odean Ebel, head of the farmers' committee, is more expensive to produce with irrigation than as a dryland crop, at current prices. As for alfalfa, Ebel and others see little likelihood that farmers would shift to this feed crop. They say feedlot owners have been going bankrupt with some regularity lately, both because of low beef prices and the fact that cattle raising is not very profitable in a climate with North Dakota's long and bitter winters.

One environmentalist polled over 100 farmers in the Souris loop to the North, and only found one who wanted to irrigate. The climate is best suited to wheat, which is not irrigated.

Ebel estimates that in the state, which is 90 percent farmland, "5 percent are strongly opposed, 5 percent strongly for, and the rest don't give a damn." Those who favor the project, he continues, are "those who stand to gain financially, those who stand to gain politically, and those being paid to promote it."

There is one area, the Oakes area at the south end of the planned system, where there is considerable support for the project. However, a look at the region, dotted with prairie potholes and a number of crops already under irrigation (from wells) lends some credence to the assertion of one biologist that what the farmers really want is free drainage so they can expand their cropland.

Critics are also skeptical that the Garrison project is required to meet municipal water needs. One town, Minot, has signed a contract for water, and it subsequently discovered its own aquifer. Other towns do need water, but most are in the west, outside the conservancy district. Furthermore, municipalities require only a tiny fraction of the water required to irrigate, and their needs could be served by pipelines alone.

Even assuming a favorable economic picture, nagging environmental problems remain. One is the famous fish screen, demanded by Canada to prevent interbasin transfer of biota. Much arduous engineering has gone into the design of a $42-million screen for the McClusky Canal to prevent organisms from getting into the Lonetree Reservoir. When *Science* asked the men at the conservancy district how recent tests had gone, they said the screen worked wonderfully and that buildup of algae against it was prevented by a backwash system.

Other sources, however, indicated that the screen is still a "terrific problem." The screen, with 4900 holes per square inch, is fine enough to eliminate fish eggs, but experiments with a small test screen resulted in a buildup of algae and debris that radically reduced the flow. The big screen is actually 168 large tilted panels that would cover a large area where water rushes down from the canal into the reservoir. This end of the canal is in the Hudson Bay Basin, so if the screen failed, it would be too late to effect an emergency downstream cutoff.

A screen at best could never be 100 percent effective, nor would it prevent the passage of fish disease organisms. So the Bureau of Reclamation is looking into various means of creating a "second line of defense." At a 5000-acre test area in Oakes, investigators from state and federal agencies are looking at ways to prevent noxious organisms and chemicals from getting into Canadian waters. These include underground drainage pipes and recirculation of wastewater.

The spokesmen at the Conservancy District regard all the "so-called problems" of the project as actually one problem: environmentalists. "If God was going to create the world today he'd never get it through" (the environmental impact process) sighed one.

The chief concern of environmentalists is the project's impact on wetlands. North Dakota, according to the Audubon Society, has "the last best prairie wetland habitat on the face of the Earth." Originally totaling 5 million acres, more than 2 million remain despite widespread drainage for cropland. Over the millenia, each marsh has developed its own ecology, arising from soil differences and water ranging from pure to saline. Some are permanent, others dry up seasonally.

Thus, even the most dedicated efforts at "acre for acre" replacement of wetlands—as desired by environmentalists and, originally, by the Fish and Wildlife Service—could not result in full replacement of the lost habitat.

Phase I entails the destruction of 19,000 acres of wetlands, including the Cheyenne Wildlife Refuge, as well as damage to 6 other refuges. The plan for mitigation of the impact does not attempt to replace all these losses. Instead, it employs a technique developed a few years ago by the Fish and Wildlife Service called Habitat Evaluation Procedure. This involves the development of a numerical rating, expressed in Habitat Units, of an environment as it relates to the needs of a particular species. The rating is arrived at by multiplying a figure representing the quality of a habitat by its acreage. Species with the same needs are lumped in the same "guild" for the purposes of evaluation. Thus the muskrat is linked up with the canvasback and redheaded ducks. If the habitat is suitable, it is assumed that other elements, such as food supply and predators, will fall in line.

The values of the plan are ultimately expressed numbers of animals accommodated, rather than duplication of habitat. Thus, the 19,000-acre loss is to be matched by a gain of 4000 acres (created by reflooding drained wetlands), supplemented by the purchase of 7000 acres of existing wetlands (plus surrounding grasslands). The Bureau of Reclamation confidently predicts that intensified management—such as the construction of fencing and nesting cover in surrounding uplands—will result in enhancement of the waterfowl population.

There have been some liberties taken with the procedure—reportedly despite protests from Fish and Wildlife Service biologists. When it was found, for example, that there wasn't going to be enough muskrat habitat, the overall numbers were straightened out by tacking on some excess habitat units for gadwall ducks (for "out-of-kind" mitigation).

The plan has drawn some sharp criticism. The North Dakota chapter of the Wildlife Society, a professional group, damned the mitigation plan as one that might be expected from "a crash program, dominated by people without professional wildlife management expertise, to develop a . . . plan to meet political objectives."

The Minnesota Department of Natural Resources has also criticized it, saying that the models used are "inadequate and misleading," that wetland losses are written off while grassland values are inflated, and that the "models have not been verified in reality."

White-faced glossy ibis. Its only North Dakota nesting place is in jeopardy.

Environmentalists consider this mitigation plan a "farce." Former Fish and Wildlife Service biologist Gary Pearson says the procedure is "conceptually valid if we could identify all the elements going into quality of habitat." But, he said, if we had that kind of data "we could shut down waterfowl research across the country."

Environmentalists are particularly disturbed over plans to inundate Kraft Slough in the Oakes area, one of the most complex and valuable waterfowl habitats in the state, for the Taayer Reservoir. Kraft Slough provides nesting or migration habitat for 40 percent of the state's migratory bird species. It has white pelicans, of which there are no more than 50,000 in the world; whistling swans who fatten on the sago pondweed; and the state's only nesting habitat for white-faced glossy ibises.

Kraft Slough, says former Audubon worker Richard Madson, who has made a career of battling Garrison, "is where environmentalists draw the line in the sand." Kraft Slough, says the conservancy district, is the only feasible place in the area for a reservoir.

By now, foes of the project have become openly cynical. Says one farmer: "in the old days Garrison dam was never called a 'sacrifice.' We said we're going to get a big manmade lake and cover a lot of ugly old Indian reservation land." Many regard the project as purely political, designed to line selected pockets. A federal agency employee observes: "When you go to meetings [held by the conservancy] you see not farmers but bankers, agribusiness, and chemical people."

A Bismarck official believes that project supporters' stubborn resistance to compromise stems from their "great fear that if they show any sign of weakness the whole thing will crumble," and they will be left with no project.

Whatever their motives, Garrison promoters have been stubbornly clinging to the vision of the state's needs that emerged from the dust-bowl days. Environmental awareness has scarcely begun to suffuse this thinly populated state. "The fact that a name was affixed to the Cheyenne Wildlife Refuge does not mean it was set aside in perpetuity to frustrate development forever," asserts lawyer Sagsveen.

The need for agreement on a workable plan is becoming more urgent if North Dakota is to make good its claim to Missouri water. This is the only major river not covered by an interstate compact. Agricultural states to the south are already casting around for diversion projects to compensate for the drying up of the Ogallala aquifer, which has been overexploited for many years.

As the new commission, which will have offices in Washington, D.C., Bismarck, and Denver, gets to work, the earth movers are racing back and forth on the next canal, and bulldozing is progressing apace on the Lonetree Dam. The more that can be accomplished before work is suspended, the more reason to complete the job, according to one common strain of logic. Or, as a Fessenden storekeeper put it: "They've made such a mess already, we might as well let them finish—something good's bound to come of it."—**Constance Holden**

Ms. Holden is a reporter for Science Magazine, News Department.

THE COLORADO RIVER
RIVER OF CONTROVERSY
by Robert Coats

In November 1922, delegates meeting at Bishop's Lodge near Santa Fe reached agreement on a Colorado River Compact to allocate waters of the Colorado River between the upper and lower parts of the basin. In May 1983, a group of citizens and water experts gathered at the same location to consider present problems and future options in the management of the Colorado River.

The"Colorado River Working Symposium: Management Options for the Future" was convened by the Center for Natural Resource Studies (under the co-chairmanship of F. Lee Brown and Gary Weatherford, with funding from the William H. Donner Foundation and General Services Foundation). Attendance was limited by invitation to 70 participants and observers, including an array of leading legal authorities, water managers, interest group representatives, public officials, and water users. The purpose of this symposium was to stimulate, in a neutral forum, free-wheeling discussion of the severity of Colorado River problems and of possible solutions.

A theme stressed throughout the four-day symposium was that the institutions and mechanisms for allocating water in the basin developed during an era of rapid growth and development. With the available water supply fully appropriated (or arguable overappropriated), those institutions will be seriously tested. New initiatives, better suited to an era of water management, predictably will be required.

Ironically, the symposium was held during a year of extraordinarily high runoff in the Colorado River basin. In most years, however, the runoff is less than was projected when rights to the river's water were divided among nations, regions, states, and users. A brief respite of plenty is perhaps the best time to be thoughtful about the longterm problems of water shortage.

In his keynote address, Governor Bruce Babbitt of Arizona urged competing water claimants "to move away from endless and unpredictable lawsuits as a means of resolving Colorado River conflicts." "The reality of rising salinity in the Colorado

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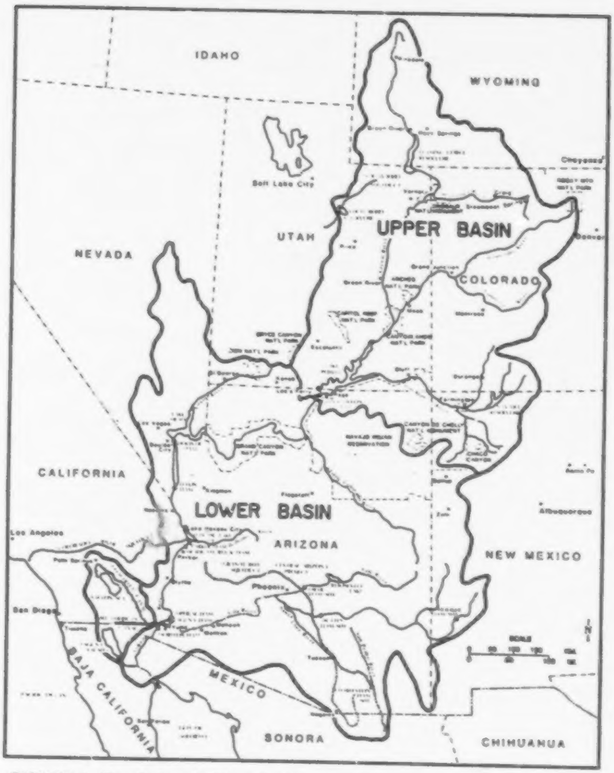


FIGURE 1. The Colorado River Basin.
SOURCE: Center for Natural Resources Studies of JMI, Inc

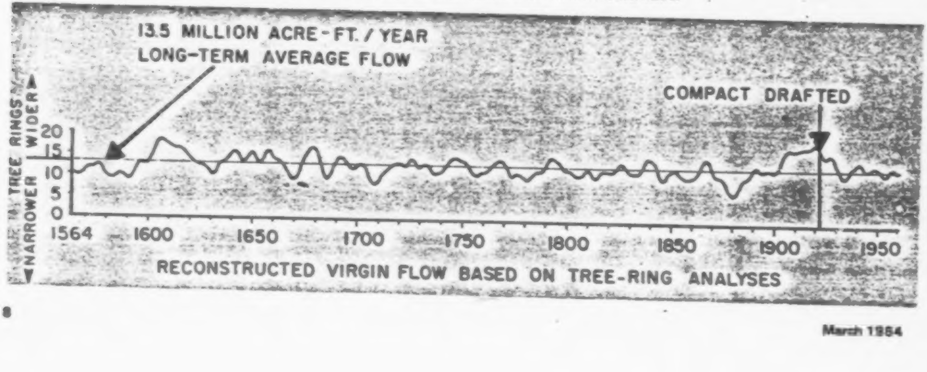
system will be upon us sooner than later," he warned. The " 'Law of the River,' made up of a host of compacts, court decisions and other rules, has served the past sixty years well," Babbitt said, "but it manifestly does not provide adequate guidance on the major issues of the next century."

He charged the participants to consider alternative forums and strategies for meeting the wide range of problems unanticipated when major river allocation and management decisions were made decades ago. "The adversary model is no longer relevant or appropriate," Babbitt emphasized. He suggested the consideration of, for example, possible congressional hearings in the West as one step in the process of searching for new approaches and institutional mechanisms to cope with the region's water resource problems.[1]

Regional Conflict

The cornerstone of the body of the law known as the Law of the River is the Colorado River Compact. The history of the compact and the interplay of regional conflict that brought it into being were sketched for the workshop participants in a fascinating pre-symposium background paper by Norris Hundley, Jr.[2] Alarmed by rapid growth of California's urban and agricultural demands on the river, the upper basin states began in 1920 to push for a compact

FIGURE 2. Reconstructed streamflow in the Colorado River at Lee's Ferry, 1546–1971. Early estimates (below) are based on tree ring sizes; later figures (across) are mentioned in million acre-feet.



that would secure a water supply for their own development. Particularly alarming to the upper basin states was a call by Southern California interests for a storage reservoir and hydroelectric plant "at or near Boulder Canyon." Under the doctrine of "prior appropriation," future development opportunities in Colorado, Utah, Wyoming, Arizona, and Nevada could be foreclosed by growth in Southern California.

The intent of the framers of the compact was to divide the flow of the river equally between the upper and lower basins (see Figure 1). Based on data available at the time, the compact required a 10-year running-average flow of at least 7.5 million acre-feet per year at Lee's Ferry. However, as several papers given at the workshop noted, more recent hydrologic data suggest that mean annual flow at Lee's Ferry is closer to 14 million acre-feet rather than the 16.4 million acre-feet assumed by the compact.[3] There simply is not enough water in the river to provide each part of the basin with 7.5 million acre-feet per year as well as to meet the treaty obligations with Mexico and to provide for Indian claims and losses to evaporation.

What is more, historical evidence suggests that a deep and prolonged drought is a significant possibility, although no one can say when it will occur (see Figure 2).[4] The framers of the compact were unaware that they were working with data from the wettest period since the 1600s.

Although the compact provided some assurances to the upper basin states, it provided for no division of water between states within each part of the basin. Fearing that California would take most of the lower basin share first, Arizona balked and refused to join the compact. The result was a six-state compact. Subsequent upper basin opposition to the Boulder Canyon Bill was withdrawn in exchange for California's agreement to limit its use to 4.4 million acre-feet plus no more than half the unapportioned surplus.

After futile attempts at bargaining with California for a more favorable division of the lower basin share, Arizona sought relief (unsuccessfully) in the U.S. Supreme Court. Finally, in 1944, Arizona joined the compact and two years later was rewarded with the Bureau of Reclamation's plan for the massive Central Arizona Project (CAP) to bring water from the river to the Tucson and Phoenix areas. Congress, however, refused to authorize the CAP until Arizona and California settled their differences; and so, in 1952, Arizona again asked the Court to apportion the lower basin's water.

The suit, *Arizona v. California*, decided in 1963, was a victory for Arizona. The state was awarded 2.8 million acre-feet plus all of the water originating in its tributaries, about 1 million acre-feet. But Arizona interests had still not won authorization for the CAP.

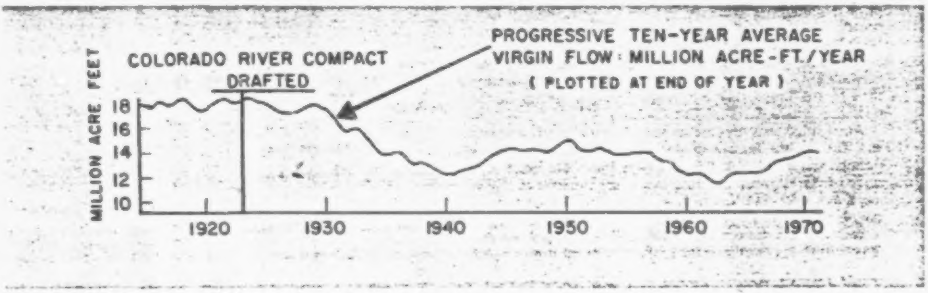
Later, in bargaining for a 1968 authorization, Arizona guaranteed 4.4 million acre-feet per year to California, and agreed to support authorization for 5 new projects in the upper basin. As Hundley noted, "The maneuvering for concessions produced a bill authorizing projects for which the water supply was likely to be inadequate."[5] Thus, the problem of managing demand to meet a limited supply was passed on to the future.

Conflict between the upper and lower basins will no doubt continue to be a major issue, and one in which equity arguments as well as legal and political battles play a role. As conference participants Helen Ingram, Lawrence Scaff, and Leslie Silko argued,

> *It is patently unfair for the claimants who have yet to develop to carry the entire burden for previous decisions overestimating the amount of water in the river and underestimating claims of Indians and Mexicans and the possible adverse environmental consequences of overbuilding on the river. The obligation for satisfying all legitimate claims that exist on the river belongs especially to the lower basin users, whose interests have been for so long so well served.*[6]

Conflict with Mexico

The Colorado is an international river, providing water for agricultural



SOURCE: C. W. Stockton and G. C. Jacoby, Jr., "Long-Term surface water supply and streamflow trends in the Upper Colorado River Basin," *Lake Powell Research Proj. Bulletin No. 18,* Institute of Geophysics and Planetary Physics, University of California, 1976.

PHYSICAL CHANGES IN THE RIVER

The Colorado River between Lake Powell and Lake Mead is a very different river than the one explored by John Wesley Powell in 1869. Before Glen Canyon Dam was built, the mean annual flood was 3.5 times the present 800 cubic meters per second. Alluvial fans of large boulders deposited at tributary mouths are responsible for most of the rapids in the Grand Canyon. With reduced flood flows, the debris at tributary mouths is moved less frequently. Consequently, the alluvial fans and the rapids are growing.[a]

Lake Powell removes almost all of the fine sediment and organic debris transported from the upper basin. The scour and replenishment of beaches is a dynamic process, but replenishment requires a source of sand. During the record flood of 1983, beaches below Glen Canyon Dam were scoured away. Although new beaches were formed in the lower canyon, the loss of beaches in the upper Grand Canyon may be permanent. Sediment transport through the canyon is the object of an ongoing million-dollar study by the Bureau of Reclamation and the U.S. Geological Survey.

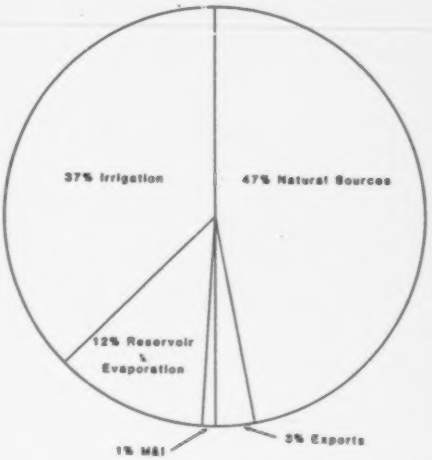
Flooding in 1983 was caused by unusual spring weather combined with inadequate flood storage space. Current flood control regulations and operating criteria for the dams on the Colorado and its tributaries enable reservoir operators to maximize power generation and water supply at the expense of flood control.[b]

Lake Powell has had a profound effect on the biotic resources of the canyon. Before the dam, riparian vegetation was periodically removed by high flows. Now, a new riparian plant community extends from Glen Canyon Dam to Lake Mead.[c] The river now runs cold and clear. Trout planted near Lee's Ferry have spread upstream to the dam and downstream almost to Lake Mead, but the endangered humpback chub has been all but extirpated.[d] The potential for ecological damage through the Grand Canyon presently has no bearing on the operating criteria for Glen Canyon Dam.

When air conditioners are turned on for the day in Phoenix and Tucson, the Bureau of Reclamation increases the flow through the turbines at Glen Canyon Dam. The result is a surge of flow downstream that may cause the river to rise as much as six feet in a few minutes. Experienced river runners call the surges "tides," and plan their arrival at difficult rapids to coincide with the optimum flow level.[e] The rapid rise and fall of the river exacerbates the problem of beach erosion. The Bureau of Reclamation plans to increase the generating capacity at the dam, which would lead to even greater daily "tides."[f]

The most serious water quality problem in the Colorado River is salinity. Dissolved salts enter the river system from naturally occurring springs and saline groundwater, irrigation return flows, and municipal and industrial discharges. Evaporation and transpiration from reservoirs, irrigated fields, and phreatophytic (water-loving) vegetation increase the concentration of salts by reducing the volume of water.

FIGURE X. Sources of salinity in the Colorado River at Hoover Dam.



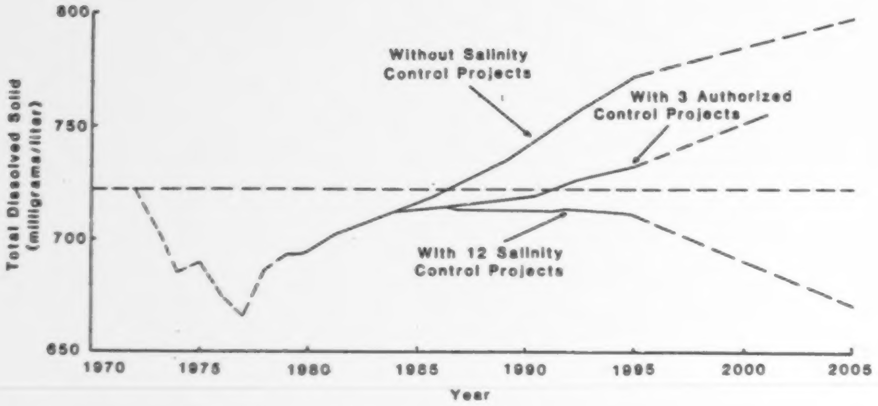


FIGURE Y. Projected salinity at Hoover Dam.

Without salinity control, damages to agricultural and industrial users in the lower basin could reach $237 million per year by the year 2000.

Figure X shows the sources of the present salinity concentration at Hoover Dam.[g] Figure Y, from the 1981 report of the Colorado River Basin Salinity Control Forum,[h] shows the approximate present and projected salinity concentration at Hoover Dam, under various assumptions. The numeric criterion adopted by the Forum (723 mg/1 total dissolved solids) is also shown.

The assumptions used in the projection are optimistic. They include no salt return from industrial discharges, reformulation of authorized federal water projects to minimize salt contribution, a relatively low level of future development, and a "virgin flow" at Lee's Ferry of 14.0 million acre-feet per year. If the annual flow of the river is somewhat lower (13.0 million acre-feet per year) or the rate of development in the basin is "moderate" to "high," then the salinity criteria will probably be exceeded at times, even with 12 of the proposed projects of the Colorado River Water Quality Improvement Program in place by 1995. Some of these proposed projects, however, may not prove to be cost-effective. Clearly, meeting the numeric water quality criteria for salinity in the lower river will be a difficult challenge.

The proposed units of the Bureau of Reclamation's Colorado River Water Quality Improvement Program include projects to control natural inflow of saline groundwater, to control saline return flows from agriculture, and to control non-point sources.[i] A 1981 study by the Bureau of Reclamation concluded that local use (within less than 100 miles) of saline water for energy production (i.e., cooling towers and coal slurry pipelines) is one of the most cost-effective ways to remove saline water from the river. Long-distance transport purely for salinity control is generally not cost-effective.

As with most water conservation and management issues, there are serious legal and institutional obstacles to diverting and utilizing saline groundwater.[j] For example, some states do not recognize salinity control as a beneficial use, and there is no explicit authority for purchase of water rights for salinity control purposes. Most of the salinity-control options are in Colorado and Utah; if substantial volumes of water are removed from streams of these states, they could bear most of the burden and reap few of the benefits. Furthermore, some of the best control options involve interstate transfers of saline water. Procedures exist to allocate water among states in the upper basin, but there are no procedures for intrabasin exchanges among lower basin states, nor from upper to lower basin.

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[a] A. Howard and R. Dolan, "Geomorphology of the Colorado River in the Grand Canyon," *J. Geology 89:269–298.*

[b] William Vandivere and Peter Vorster, *Hydrologic Analysis of the Colorado River Floods of 1983*, unpublished report for Friends of the River (San Francisco: Philip Williams and Assoc., 1983), 12 pp.

[c] R.M. Turner and M.M. Karpiscak, *Recent vegetation changes along the Colorado River between Glen Canyon Dam and Lake Mead, Arizona*, U.S. Geol. Surv. prof. paper 1132 (Washington, D.C., 1980), 125 pp.

[d] Steven W. Carothers, S.W. Aitchison, and R. Roy Johnson, "Natural resources, white water recreation, and river management alternatives on the Colorado River, Grand Canyon National Park, Arizona," First Conference on Scientific Research on the National Parks, New Orleans, La., 1976, pp. 253–259.

[e] Roderick Nash, "Wilderness values and the Colorado River," draft paper for CRWS, 1983, 17 pp.

[f] Philip Williams and William Vandivere, *Review of the Environmental Assessment for the Glen Canyon Powerplant Uprating*, unpublished report (San Francisco: Philip Williams and Assoc., 1982), 24 pp.

[g] U.S. Dept. of Interior Bureau of Reclamation, *Salinity update special edition* (Wash., D.C.: Government Printing Office, October 1981), 12 pp.

[h] Colorado River Basin Salinity Control Forum, "Water quality standards for salinity/Colorado River system—Proposed report on the 1981 review."

[i] U.S. Dept. of Interior Bureau of Reclamation, *Special report: Saline water use and disposal opportunities, Colorado River water quality improvement program* (Denver: Colorado River Water Quality Office, September 1981), 15 pp.

[j] Ibid., p. 10.

development in the rich Mexicali Valley. In 1944, after decades of haggling, the United States and Mexico agreed on a division that gave Mexico 1.5 million acre-feet per year, or slightly less than the State Department believed Mexico was then using. The treaty was bitterly opposed by California, which by that time had built extensive aqueducts and was using nearly a million acre-feet per year of surplus above the 4.4 million acre-feet. Other states supported the treaty, and it was ratified by Congress in 1945.

The question of water quality, however, was not addressed in the treaty. As agricultural development on the U.S. side proceeded, the salinity from return flows increased. The final blow came with the 1961 completion of the Wellton-Mohawk drainage channel, which discharged saline return flows just above Mexico's main diversion canal intake. The concentration of salt at the border jumped to 2,700 parts per million, causing crop damage in the Mexicali Valley. Mexico protested vigorously and threatened to take its case to the International Court of Justice.

By increasing the release of good-quality water and relocating the Wellton-Mohawk outfall, the United States was able to alleviate the problem temporarily. In 1973, an agreement was reached that guaranteed water of satisfactory quality to Mexico. To achieve this, the Colorado River Basin Salinity Control Act of 1974 authorized upstream salt-control projects and the construction of one of the world's largest desalinization plants, scheduled for completion in 1987. Although cheaper alternatives to the desalinization plant were available, they were not considered for a variety of institutional reasons.[7]

Attorney Edward Clyde noted that the treaty is a national obligation, not just a state or regional obligation. If means are found to augment the supply of the Colorado (such as transfer of water from the Missouri or Columbia River basins), then the basin states would be relieved of their obligations imposed by the compact.[8] Allen Kneese and Gilbert Bonem suggested that the treaty could be used as leverage to push for interbasin transfers.[9]

Although the intent of the compact was to obligate the upper and lower basins equally for delivery to Mexico, the upper basin is only responsible for delivery at Lee's Ferry. Channel losses and evaporation between Lee's Ferry and the border must come out of the lower basin share, according to Clyde.[10]

Further, the treaty says nothing about timing of delivery in a given year. Since the precipitation in water year 1983 has been so high, 1,168,000 acre-feet were spilled from Hoover Dam in January 1983 to allow for flood control capacity. This is about 737,000 acre-feet in excess of downstream requirements for January. The release may be counted against the treaty obligation (1.7 million acre-feet this year), even though Mexico cannot use much of the water.[11]

Indian Water Rights

Indian water rights were given little consideration in the Colorado River Compact, which simply states: "Nothing in this Compact shall be construed as affecting the obligations of the United States of America to Indian Tribes." Herbert Hoover called this the "Wild Indian Article," but, as it turns out, the Indians were dealt a wild card. According to the "Winters Doctrine," set forth in a 1908 court case, establishment of an Indian reservation implied the reservation of rights to enough water to develop "irrigable lands" on the reservation. Since Indian reservations generally predate non-Indian water claims, Indian water rights have a fairly firm legal base.[12]

There is an important distinction, however, between "paper water" and "wet water." Reservations along the Colorado are lacking water distribution and irrigation facilities, and the Indians lack the capital to build them. By the late 1970s, about 60 percent of the irrigable acreage on Indian lands along the river was under cultivation, but only 8 percent was being cultivated by Indians.[13] Local political pressure on the federal government does not, of course, favor federal aid to help the Indians utilize the existing rights. Since the reservations are lacking in capital to develop either sufficient agriculture or industry, some Indians have been willing to bargain away water rights in exchange for development.

For example, in exchange for the Navajo Indian Irrigation Project, the tribe agreed to waive its priority on the San Juan River. In exchange for a coal-fired power plant, the tribe agreed to limit its demands on the Little Colorado to 50,000 acre-feet per year. These arrangements, which are seriously questioned by some Navajos, suggest that, in a free market for water rights, the Indians might be separated from rights to water they are not currently using. As Ingram, Scaff, and Silko put it, "In the West, water has gone to those with political power, legal skills, technical knowledge and sheer tenacity; others have been excluded."[14]

The Hopi and Navajo tribes are presently involved in litigation against Arizona on the Little Colorado, and the Navajos reportedly have been preparing a case against the state and federal governments on the Colorado. The suit is expected to be for at least 5 million acre-feet, which considerably exceeds any one state's entire share of the river.[15]

Conflicts over Use

With all of the water in the basin appropriated, and no immediate prospect of importations from other basins, any new consumptive uses must take water from existing uses. Little wonder, then, that conflicts over use are often sharp and clear-cut. Some of the issues that emerged at the workshop are:

I. Wilderness Values and Instream Uses

In the three decades since the early 1950s, a whole new set of demands and pressures for "use" of the Colorado River has developed: the pressure for wilderness experience and maintenance of instream flow values. These values and political pressures were set forth at the workshop by Roderick Nash, noted historian on wilderness in the American experience.[16]

Figure 3 (from data presented by Nash) shows the exponential growth of travel on the Colorado River through the Grand Canyon. In 1972, over 16,000 people floated the canyon, and the Park Service imposed a permit system. The popularity of the Colorado River wilderness experience did not grow by word of mouth alone, but was greatly enhanced by the writings of Wallace Stegner, Edward Abbey, and publications of the Sierra Club.

As pressure for water development grew, so did the political experience and political acumen of wilderness advocates. The first major fight began in 1952, with a bill in Congress calling for major reservoirs on the Green River at Echo Park and at Glen Canyon on the main stem near the Arizona-Utah border. The Echo Park reservoir would have flooded the canyons of Dinosaur National Monument. To stop the Echo Park dam, preservationists mounted what Hundley called "the biggest battle over wilderness preservation since John Muir tried to keep a dam out of Hetch Hetchy Valley . . . ."[17]

After several years of struggle, the dam proponents gave in, and the bill went forward for a dam at Glen Canyon. To many who floated Glen Canyon before it was flooded by Lake Powell, however, the failure to oppose that dam was a major mistake that cost the loss of a unique treasure.

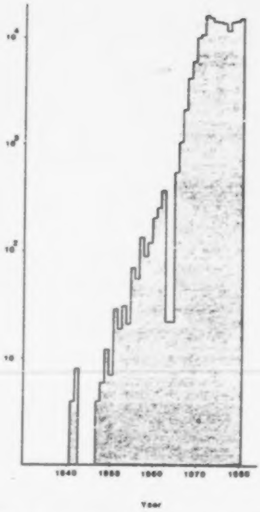

FIGURE 3. Number of persons floating the Colorado through the Grand Canyon, 1941–1981.

SOURCE: From figures of Roderick Nash, draft paper for CRWS, 1983.

Next came proposals for dams in the Grand Canyon itself. The original bill for the CAP included a dam at Marble Canyon, just east of the main gorge of the Grand Canyon, and a dam at Bridge Canyon. Both dams would have flooded scenic areas. The reservoir at Bridge Canyon would have inundated portions of Grand Canyon National Park and Grand Canyon National Monument. Preservationist groups mounted another major lobbying effort, and the CAP bill that was finally passed in 1968 deleted the dams and substituted a coal-fired power plant at Page in northern Arizona.

With the growth of environmental awareness during the 1970s, both conservationists and public agencies became increasingly conscious of the importance of river flow regimes to wildlife and fish habitat. By maintaining some minimum flows below a project dam or properly managing

(*continued on page 36*)

River of Controversy

(continued from page 13)

reservoir levels, it is often possible to maintain a valuable recreational fishery, or to maintain minimum habitat requirements for an endangered species.

In the Colorado River basin, however, the agencies responsible for dam operation are locked into release schedules by operating manuals that are based on requirements of the U.S.-Mexican treaty and the compact, requirements for hydroelectric power, and requirements of irrigators. Among the states in the basin, only Colorado recognizes an instream flow "water right."[18] Instream flow requirements for fish habitat do, however, figure in the controversy over new projects.[19]

II. Timing of Releases

Irrigated agriculture has provided the impetus for much of the water development in the basin, but the generation of hydroelectric power is assuming increased importance. Sale of power generated at Glen Canyon Dam has brought in the revenue to finance a dozen or so "participating projects" elsewhere in the upper basin, including the Central Utah Project.

David Getches and Charles Meyers noted the conflict between timing of releases for power production and timing for irrigation.[20] Among the questions they raised are:

- Can the lower basin demand delivery of its share of water when it is not needed for agricultural and domestic uses so that it can be used for hydroelectric power generation?
- Does it matter whether such deliveries will result in reduction of upper basin agricultural and domestic uses or whether they can be accommodated simply by releases of stored water?
- Can the lower basin demand that excess stored waters (over the compact entitlement) be delivered solely for power generation?
- Can the upper basin have credit against its compact obligation for any excess releases made to generate power but demanded for lower basin uses?

Answers to these questions, however, would still not provide a release schedule that would optimize both power production and irrigation timing. Solution of the problem would require a complex and sophisticated model, and the solution might be severely constrained by the present institutional arrangements.

III. Agriculture vs. Other Uses

As interest in the exploitation of energy resources in the Colorado River basin picks up after the current recession, the conflict between agriculture and municipal and industrial uses will sharpen. Getches and Meyers put the question bluntly: "Can agricultural uses compete politically and economically with municipal and industrial uses in the future?" As they pointed out, the Law of the River "bristles with favoritism for agricultural interests," and the notion of an agrarian democracy of small, independent freeholders is firmly embedded in the American subconscious (though not necessarily in reality).

Municipal and industrial uses, however, can command a much higher price for water than irrigated agriculture. Institutional barriers to transfer of water from a "lower" to a "higher" use result in an inefficient allocation of resources. Del Gardner.

in his defense of the untried market approach to water allocation, cited examples of such misallocation.[21] Such inefficient use of water is commonplace, according to Gardner, where allocation is accomplished by political and institutional means rather than a free market.

IV. Efficiency vs. Equity

Economic efficiency is not necessarily the highest attribute of a civilization, however. Equity considerations are equally important. Ingram, Scaff, and Silko have commented that "the equity perspective on Colorado River issues is not just high-flown idealism. It simply makes good sense."[22] They see water as both a social good and resource whose control and distribution has important implications for the values of a democratic society.[23]

Are efficiency criteria alone adequate to measure the value to society 30 years hence of maintaining stable rural-agrarian communities? Del Gardner has taken the position that they indeed are; Ingram, Scaff, and Silko clearly disagree. In the long run, they have argued, failure to take account of the equity perspective will lead to a costly and destructive "Milagro Beanfield War"[24] on a regional scale.

Future Scenarios and "Shocks"

With an issue as complex and fascinating as management of the Colorado River, it is impossible to avoid speculating about future possibilities. Such speculation was stimulated by the paper of Kneese and Bonem, who suggested a number of possible "shocks to the system":[25]

☐ *Renewed disruption of international trade and an urgent national need to find and develop energy resources in the western hemisphere.* Although there is presently an international oil glut, this situation cannot last long. With either renewed economic growth or a large war in the Middle East, the United States could again face a severe energy shortage. The requirements, Kneese and Bonem argued, could not be met from basin sources without disastrous effects on the region's agriculture.[26]

☐ *Indian water claims are quantified, and quantities are large.* A major uncertainty in the Indians' water rights claims concerns the extent and definition of irrigable acreage. The Navajo situation dramatizes this issue. If only 500,000 acres, or four percent of the Navajo reservation, are *practicably* irrigable, the Navajo entitlements would be about 2 million acre-feet per year, and could be as high as 5 million acre-feet. Combined Indian entitlements could thus amount to almost half of the long-run yield of the river.

☐ *A major drought or prolonged wet period.* The difficult problem of long-term climatic fluctuations was recognized at the symposium. The question is not *if* drought will occur, but *when*. Droughts of 10-years' duration with a mean annual flow between 9.7 and 11.8 million acre-feet have occurred twice in the last 400 years. Kneese and Bonem estimated that *if* reservoirs were full at the beginning of the drought, and *if* they are emptied during the drought, and *if* there is no future increase in development, then the upper basin could meet its own needs, and its compact obligations, and still have a little to spare; but local shortages would occur throughout the basin.

It is likely, however, that demands will continue to increase, and that the reservoirs would be operated conservatively during a drought. Kneese and Bonem concluded that "if a ten-year drought starts 15 to 20 years from now, it is unlikely that the upper basin can make good its compact commitments even under these extremely favorable assumptions."

Currently we are in a wet phase of the cycle. Two-year precipitation totals have broken historical records over large areas of the West. It is unlikely that the present situation represents a permanent change, but rather merely a fluctuation. The long-term danger is the complacency and optimism that accompanies a period of wet years. It was with such optimism that sod busters settled and farmed the short-grass prairie region west of the 100th meridian. Pundits derided the "Great American Desert" as a myth, and even promoted the notion that "rain follows the plow." The drought of the late 1880s drove the settlers out of the country, or drove them mad.[27]

Possible Solutions

☐ *Importation of new supplies.* A number of workshop participants put forward ideas for possible solutions or approaches to the problem. Mentioned was the possibility of what Kneese and Bonem called the "last and greatest Christmas tree" of traditional distributive water politics to build a system for massive water transfers from the Pacific Northwest. The secretary of the interior was prohibited by the CAP legislation from studying the feasibility of out-of-basin transfers, a prohibition that has been extended to 1988.[28] In the face of a prolonged oil shortage, it is not hard to imagine a coalition of northeastern and southwestern states pushing through a trade of northwestern water for Mexican oil. The degree to which such a trade would represent a long-term "solution" can be questioned.

☐ *Market pricing of water.* Del Gardner's provocative paper on the market approach to water allocation stimulated considerable discussion. Surely a water market would result in higher prices to agriculture, and would provide a strong incentive for water conservation. Upper basin agriculture might have a hard time competing with the Imperial Valley, which could pay a much higher price for water. Political resistance to a completely unfettered water market would probably be insurmountable, but some local water markets might be possible.

☐ *Conjunctive management of groundwater and implementation of conservation technologies.* The intimate hydrologic connection between groundwater and surface water is well recognized, but under law, the two systems are often treated as if they were separate and distinct. Different states in the basin have very difficult laws and policies for groundwater. The benefits of conjunctive management of groundwater and surface water were mentioned by several workshop participants. Clyde expressed the opinion that if curtailment of use within individual states becomes necessary, then the entire tributary system within each state, including groundwater, should be administered as one system.[29]

Installation of modern irrigation technology could save significant amounts of water. Such practices include trickle or spray irrigation rather than flooding, lining irrigation ditches, etc.[30] But as Getches and Meyers have pointed out, the compact formula provides a disincentive to conserve in the upper basin, since the lower basin states have first call on the surplus. The doctrine of prior appropriation itself ("use it or lose it") is additional disincentive to conserve. Navajo fears of losing water rights, for example, led to development of an irrigation project on marginal lands that has been plagued with problems.[31]

☐ *Renegotiation of the compact.* Paul Bloom, former general counsel of the New Mexico Interstate Stream Commission, proposed a fresh look at the interstate compact as a vehicle for resolving water conflicts on interstate streams.[32] He suggested that "Congress should legislate a time certain, after which the failure to reach good faith compromises among the states and United States will result in mandated apportionment litigation, a legislative resolution of the various problems." To do this, Congress would have to order the relevant federal agencies to produce a list of streams on which failure to reach agreement is preventing planning and development of water resources. Congress could then allocate funds for technical studies and the president could be required to appoint a special representative to quantify and advocate Indian claims.

Failure of the states to agree on a compact settlement written in a specified time period would trigger either federal allocation legislation or a Supreme Court apportionment decision. Such an arrangement, Bloom suggested, "will ideally focus the minds of state and federal agency personnel on the necessity of making the political compromises necessary to effect a solution."

Summary and Conclusions

The summation address at the symposium was delivered by Gilbert White, hydrogeographer at the University of Colorado.[33] White identified seven major issues that consistently emerged from the presentations and discussions. These are:

- ✓ What is the optimum allocation of water to various uses? What is "consumptive use" and "surplus water"?
- ✓ What structural and nonstructural measures are appropriate to deal with the salinity problem, and how should responsibility be allocated?
- ✓ How significant is the failure to quantify federal reserve rights as a factor in inhibiting basin development?
- ✓ What will be the quantity, timing of determination, and transferability of Indian water rights? What effect will resolution of the questions have on the life of the Indians?
- ✓ How much water is required to maintain ecological and recreational values?
- ✓ How can water be appropriately priced to enhance flexibility of reallocation?
- ✓ What direction ought the nation take in managing the water resources of the basin?

White went on to identify 11 proposed institutional changes that were discussed. These are:

(*1*) Modify the compact, taking account of the mutual mistake concerning river discharge. There was not, however, strong support at the symposium for modifying the compact;

(*2*) Broaden the responsibilities of the Bureau of Reclamation to include social goals, including water conservation and instream use protection;

(*3*) Speed up quantification of Indian water rights;

(*4*) Speed up specification of federal reserve rights;

(*5*) Add parts of the Colorado River to the National Wild and Scenic River System;

(*6*) Strengthen state permit systems to promote water conservation, eliminating perpetuity rights;

(*7*) Facilitate market transfers and pricing, with public controls;

(*8*) Establish a system of fees for water use to facilitate salinity management;

(*9*) Harmonize aims and methods of water management at the local and sub-basin level by local consultation;

(*10*) Establish a Basin Forum or Commission to bring together relevant interests in and beyond the basin; and

(*11*) Carry out an information program, perhaps producing a Water Atlas for the basin.

Rather than focusing on any particular institutional change, however, White suggested that the symposium participants should focus on "cultivating understanding of where the nation thinks it is going in dealing with the Colorado," in order to deal with the "crisis of lack of confidence" in the present direction. White noted that ". . . streams like the Colorado can flow a long distance . . . without any significant input from tributaries, . . . then be joined by a new tributary with fresh flow from other headwaters."

"We are," White suggested, "at such a point in the flow of talk about the Colorado."

ACKNOWLEDGMENTS

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NOTES

1. Gov. Bruce Babbitt, "The future of the Colorado River," address to the Colorado River Working Symposium (CRWS), Santa Fe, N.M., 1983.

2. Norris Hundley, Jr., "The west against itself: The Colorado River in historical perspective," draft paper for CRWS, 1983, 57 pp.

3. Charles W. Stockton and Gordon C. Jacoby, Jr., "Long-term surface water supply and streamflow trends in the Upper Colorado River Basin," *Lake Powell Research Proj. Bull. No. 18* (Los Angeles: Institute of Geophysics and Planetary Physics, University of California, 1976).

4. Ibid.

5. Hundley, note 2 above.

6. Helen M. Ingram, Lawrence A. Scaff, and Leslie Silko, "Replacing confusion with equity: Alternatives for water policy in the Colorado River Basin," draft paper for CRWS, 1983, 27 pp.

7. Installation cost of the desalinization plant (1973 dollars) is almost $100 million. The Bureau of Reclamation could have solved most of the problem at much lower cost by financing conversion to trickle and spray irrigation systems in the Wellton-Mohawk Irrigation District, or even by buying farms in the district and retiring them. See W.E. Martin, "Economic Magnitudes and Economic Alternatives in Lower Basin Use of Colorado River Water," *Natural Resources Journal*, January 1975, pp. 229–239.

8. Edward Clyde, "Institutional response to prolonged drought," draft paper for CRWS, 1983, 31 pp.

9. Allen Kneese and Gilbert Bonem, "Hypothetical shocks to water allocation institutions in the Colorado River Basin," draft paper for CRWS, 1983, 26 pp.

10. Clyde, note 8 above.

11. Ibid.

12. Hundley, note 2 above. In deciding *Arizona v. California* in 1963, the Supreme Court invoked the Winters principle for the five reservations along the main stem of the Colorado. Furthermore, the Court (in a supplemental decree) said that the Indians were not obligated to restrict their use of water to irrigation, but could use it as they saw fit. The Court stipulated that Indian claims are to be charged against the share of the state in which a reservation occurs.

13. Ibid.

14. Ingram, Scaff, and Silko, note 6 above.

15. Hundley, note 2 above.

16. Roderick Nash, "Wilderness values and the Colorado River," draft paper for CRWS, 1983, 17 pp.

17. Hundley, note 2 above.

18. Wayne Nelson, Gerry Horak, and Martin Lewis, *Instream flow strategies for Colorado* (Ft. Collins, Colo.: U.S. Dept. of the Interior Fish and Wildlife Service Western Energy and Land Use Team, 1978), 90 pp.

19. U.S. Dept. of the Interior, Bureau of Land Management, *Draft Environmental Impact Statement on the Allen-Warner Valley Energy System* (Cedar City, Utah, 1980), p. S-5. Habitat in the virgin river for the endangered woundfin minnow and the rare roundtail chub, for example, was threatened by the proposed Warner Valley Water Project, a 55,000 acre-foot storage reservoir near St. George, Utah, that would have been part of the controversial Allen-Warner Valley Project. A biological opinion of the U.S. Fish and Wildlife Service concluded that the proposed reservoir would be in violation of the Endangered Species Act.

20. David Getches and Charles Meyers, "The river of controversy: Persistent issues," draft paper for CRWS, 1983, 28 pp.

21. B. Delworth Gardner, "The untried market approach to water allocation," draft paper for CRWS, 1983, 26 pp. The San Marcos coal slurry pipeline from south-central Colorado to Houston would require about 12,000 acre-feet to transport about 15 million tons of coal per year, at a saving of $20 million to $130 million compared with rail transport. The same water used in agriculture in Colorado generates about $600,000 per year in profits.

22. Ingram, Scaff, and Silko, note 6 above. See also, U.S. Dept. of the Interior, note 19 above, pp. 4–26. In defining the notion of equity, the first three authors noted five basic principles:

Reciprocity: The notion that distributive advantages and costs should be shared by all members of the relevant community.

Value-pluralism: The notion that users' rights to employ water to pursue whatever values they consider legitimate should be respected, provided use does not degrade the resource or harm others.

Participation: Members of society having claims consistent with other stated values should always be accommodated in resource allocation and in the decision process.

Promises: Equity assumes the obligation to obey promises agreed to in good faith in the course of negotiation and compromise.

Responsibility: Present use of water resources should be accompanied by responsibility for future generations.

23. An example illustrates the complexity of the equity problem. Utah International, Inc., proposed to pump about 10,000 acre-feet per year from the Navajo Sandstone for a coal-slurry pipeline to transport coal from the proposed Alton Hills surface mine (Utah) for the Allen-Warner Valley Project. There is plenty of water in storage in the aquifer, but only a trickle flows out to provide surface flow to Johnson Canyon and Knab Creek, about 15 miles south of the project area. Local farms and the town of Kanab depend on this flow. There is some uncertainty about the properties of the aquifer, but enough is known to suggest that pumping could (within the 30-year life of the project) deplete the flow in Johnson Canyon (U.S. Dept. of the Interior, note 19 above). Sylvan Johnson, who farms the land settled by his grandfather in the 1870s, is able to get by, but it is unlikely that the marginal value product of his irrigation water could approach that of the same water used in the slurry pipeline.

24. John Nichols, *The Milagro Beanfield War* (New York: Ballantine Books, 1974), 629 pp.

25. Kneese and Bonem, note 9 above.

26. Kneese and Bonem suggest that the development of an additional 36,000 megawatts of electrical generating capacity, 10^{10} cubic feet/day of coal gasification, and 1.5 million barrels per day of oil shale production (over about 20 years) would require about 1 million acre-feet of water per year. With oil to trade for water, Mexico would be in a good position to bargain for a larger share of the river, perhaps an additional 2 million acre-feet.

27. Wallace Stegner, *Beyond the Hundredth Meridian* (Boston: Houghton Mifflin Co., 1953).

28. Myron Holbert, "What are the odds in future Colorado River flows," preprint for ASCE Annual Meeting and National Meeting on Water Resources Engineering, New Orleans, February 1969, cited by Kneese and Bonem, note 9 above. Indeed, according to Myron Holbert, chief engineer of the Colorado River Board of California, the authorization of the CAP was based in part on the assumption of future projects to bring new water into the basin.

29. Clyde, note 8 above.

30. Robert Stavens, *Trading conservation investments for water* (Berkeley, Calif: The Environmental Defense Fund, March 1983). Results of this study show that by financing water conservation investments in the Imperial Irrigation District, the Los Angeles Metropolitan Water District (MWD) could obtain roughly 400,000 acre-feet per year. This is about half of what the MWD takes from the Colorado, and about equal to what the MWD may eventually lose when Arizona takes its full share of the Colorado sometime after 1985. The water transfer would be considerably cheaper than expansion of the California State Water Project; net savings to the MWD would amount to $480 million over 10 years. The deal would also be in the economic interests of the Imperial Irrigation District. Both sides are optimistic that an arrangment can be worked out, but there are still some institutional obstacles to be overcome. Robert Jones, "Water agencies ponder benefits of surpluses," *Los Angeles Times*, April 28, 1983.

31. Charles DuMars, Helen Ingram, Ronald Little, Bahe Billy, and Phil Reno, "The Navajo Indian irrigation project: A study of legal, political and cultural conflict," in G.D. Weatherford, ed., *Water and Agriculture in the Western U.S.: Conservation, Reallocation and Markets* (Boulder, Colo.: Westview Press, 1982), pp. 109–135.

32. Paul L. Bloom, "The law of the river: A critique of an extraordinary legal system," draft paper for CRWS. 1983, 42 pp.

33. Gilbert White, "Transcript of summation speech at the Colorado River Working Symposium," Santa Fe, N.M., 1983, 14 pp.

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WATER SUPPLIES
A SPECIAL REPORT

Tucson's water budget is badly out of balance. Technological advances and cultural changes are in the works—but will they be enough?

Trouble in a Thirsty City

BY TONY DAVIS

TUCSON, ARIZ.—With every rain, the Santa Cruz River, which cuts through the west side of this desert city, lives. Water flows from brim to brim, beaming tantalizingly at anyone crossing one of the river's many bridges. An occasional tree trunk scurries downstream, often accompanied by tires, barrels, and other discarded bits of civilization.

When rains are too heavy, the Santa Cruz runs wild. Last October, for example, when six inches of rain fell in six days, the river swallowed condominiums, office buildings, trailers, and houses like nuggets of candy. Some people stood on the banks and cheered. They were happy, said one, "to see a river kick ass."

But the water always vanishes soon after the rain stops, leaving behind only scattered mud flats and rocks stretched across the streambed.

It wasn't always so. Before the turn of the century, parts of the Santa Cruz ran continuously—havens for herons and ideal picnic spots. By 1940, however, the river had played out its hand. The Santa Cruz became the first place in Tucson to go dry. Today many people wonder whether the rest of this growing metropolis of more than 500,000 will suffer the same fate. Indeed, "running out of water" has become a cliche here as it has across much of the West, where aridity is a way of life.

For example, in 1986 Los Angeles will lose 60 percent of its share of water from the Colorado River to the Central Arizona Project (CAP), a massive aqueduct system that will carry water from Lake Havasu to Phoenix and eventually to Tucson. If officials cannot find new sources of water, southern California could face serious water shortages during dry periods as early as 1990.

In Denver, officials limited outdoor watering for several years because of delays in building a new water-treatment plant. Now they urge residents to water outdoors only once every three days. The city recently started up a plant to test the feasibility of recycling treated sewage water for drinking. And in Salt Lake City, planners are counting on an as-yet unbuilt dam to keep them from running short of water by the year 2000.

Unlike those cities, however, Tucson has no supply of surface water and will have none until CAP water arrives in the early 1990s. Thus the city has had nowhere to go but down to the underground aquifer. Tucson is the only U.S. city of its size so dependent on groundwater. And like any veteran junkie, the city has paid a price: overpumping has dropped the water table by 180 feet in some areas.

Yet as mandated by an almost revolutionary state law—the Groundwater Management Act—officials must stop the overdraft within 40 years while keeping the 1 million immigrants expected by then from going thirsty. It can be done: Tucson is a long way from actually running out of water. But the city has run out of easy—and cheap—solutions.

Groundwater Mining

The Tucson Active Management Area of the Arizona Department of Water Resources is both a political subdivision and a desert playground. It spans 4,500 square miles of mountains, gently sloping grassland, and upland dotted with saguaro cactus and palo verde trees. Much of the region receives only 11 to 12 inches of rainfall each year—totaling 2.5 million acre-feet of water, or enough to cover 2.5 million football fields with a foot of water.

In Tucson, most of the rainfall evaporates or runs off in rivers into the surrounding desert. Only 68,000 acre-feet percolate into the aquifer. Another 71,000 acre-feet seep down from wastewater from farms and households. But every year, local residents, farms, and copper mines pump more than 400,000 acre-feet of water out of the aquifer. This process, dubbed groundwater "mining," violates a hydrologic maxim known as "safe yield," which says that less water should be pumped out than is replenished.

As the water table sinks, pumping costs soar. Water quality declines, since deeper water is more likely to be contaminated with naturally occurring salts. And officials fear that continued overpumping could cause the ground to sink—a geologic phenomenon called subsidence that can trigger fissures in the earth and cracks in buildings, streets, and pipelines. Already more than 100 earth fissures have appeared across Arizona, including one more than nine miles long. But the only hint of subsidence in Tucson has been a quarter-mile-long, four-foot-wide crack that opened up in a farming area west of the city in 1981—and no one has yet proven that subsidence was the cause. Workers for the highway department who dropped rocks, brooms, and rakes in the crack never heard them hit bottom.

Nobody worried much about safe water yield back in 1910, when the first major farming operation opened in Tucson. Owners of the Tucson Farms began raising dozens of crops on 12,000 acres—"everything but citrus," wrote George Wharton James in his 1917 book, *Arizona the Wonderland*. "There is no severe frost, and, with the abundant supply of irrigation water, drought is unregarded." He quoted

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TONY DAVIS reports on water-related issues for the Tucson Citizen.

an engineer with the U.S. Reclamation Service, a forerunner of today's Bureau of Reclamation, as saying the area had a "permanent and constant water supply."

The farm's diversion-ditch irrigation system was crude but effective. And by the 1940s, when more than 40,000 acres were being tilled in surrounding Pima County, farmers here, like farmers across the West, were using high-speed pumps that let them water twice as many acres for half the cost. Farmers then used about 85 percent of all water pumped in the Tucson area. Even today, although the city has purchased 12,000 acres of farmland for the water rights, agriculture still uses 58 percent of the county's water.

Gardens of Eden

Waves of Anglo immigrants also began arriving from the East early this century. They abandoned the area's Spanish tradition of creating small, peaceful backyard oases complete with fig trees. Instead, says Charles Sacamano, a horticulture professor at the University of Arizona here, "the thing you did was to scrape off the desert and put in a Garden of Eden."

These Edens included huge lawns peppered with non-native mulberry trees, which use 35 or more times the water that native bright-green palo verde trees use. Backyards began sporting new swimming pools at the rate of 1,000 to 2,000 a year. And golf courses, each gulping enough water for up to 6,000 persons, popped up at a higher per capita rate than any Western city except Phoenix.

The state's water laws, which gave farmers, ranchers, and other landowners the right to pump as much groundwater as they wanted, stacked the deck against conservation. Local water rates, which until the 1970s declined as one used more water, also abetted such profligacy. While the rates have increased in recent years, they haven't always kept pace with inflation. And when four City Council members voted to raise water rates sharply in 1976 to encourage conservation, they were recalled from office within months.

Fostering this wasteful spirit was "a philosophy and lifestyle of use and growth," says Marybeth Carlile, executive director of the Southern Arizona Water Resources Association (SAWARA), a business-backed group that has launched a major conservation campaign. "We've always been assured that there was plenty of water for forever."

Charles Bowden, a Tucson author and newspaper writer, carried that argument a step further in his 1977 book, *Killing the Hidden Waters*. He wrote that "to ask the economic sector to solve the problem of groundwater depletion is to ask it to self-destruct." Bowden quoted Tucson hydrologist John Harshbarger as saying that safe yield is not economically feasible, and that "experience has demonstrated that bold decisions to utilize groundwater sources in excess of natural replenishment have proved to be a realistic water management method."

That, in a somewhat parched nutshell, is how the Tucson area and the rest of the state behaved until recently. While groundwater mining made the economy tick, Arizona leaders plotted for three decades to get federal approval of the CAP. The project, whose canals and pipelines will lift Colorado River water 1,200 feet and ship it 300 miles, was finally authorized by Congress in 1968 and today is approaching Phoenix.

Arizona's water users will eventually repay much of the CAP's $3.1 billion price tag. Cities will get a bargain interest rate of just over 3 percent. Farmers will pay no interest, and their payments will be less than their share of the construction costs, thanks to a legal provision that allows them to be charged according to their ability to pay.

The CAP will provide Arizona with an average of about 1.2 million acre-feet of water a year for 50 years. But it clearly will not solve the water problem alone, since the state's total overpumping in 1980 was 2.2 million acre-feet. That year Cecil Andrus, then secretary of the interior, cracked down, threatening to withhold CAP water unless officials agreed to curb the overdraft. Thus, the state legislature passed the landmark Groundwater Management Act declaring groundwater a public resource and giving the state the power to reduce its use. The law makes safe yield a state goal and sets a deadline for the year 2025.

Dowsing for New Sources

In a variation of supply-side economics, state and local officials are counting heavily on new water sources in addition to the CAP to balance the groundwater budget. For example, Tucson is gearing up to use the area's sewage effluent, most of which now rolls out of two sewage plants into the Santa Cruz River—and then out of the area. The city will spend $35 million over the next decade on a system to carry 20,000 acre-feet of effluent annually to golf courses, parks, and cemeteries. Officials expect to eventually use all the municipal effluent, which by the year 2000 will exceed the amount of rainwater entering the aquifer each year.

The rest of the overdraft is supposed to be eliminated by a series of five state-run conservation plans. The first, just promulgated, takes effect in 1986, and each succeeding decade will see another plan. The scenario is clear: less farming and less water for everyone.

For the first time, farmers will have to measure how much water they use and pay for it. They will have to reduce groundwater pumping gallon for gallon to match the CAP water that they receive. And the state has the right, beginning in 2006, to impose a "pump tax" and use the money to buy out farmers to reduce pumping.

By 1986, farmers must install systems to pump water running off their fields back onto the fields, and they must line irrigation ditches to keep water from seeping into the soil. Farms will be allotted a maximum amount of water and must improve their irrigation efficiency—the amount of water actually reaching crops—from 65 percent today to 70 percent by 1986 and 85 percent by 2025.

Laser leveling, in which a tractor guided by a laser beam grades fields as flat as a pie pan so that irrigation water will soak in uniformly, is one possible path to that goal. Drip irrigation, which releases tiny amounts of water directly onto crops at specific times, is another. Both can achieve up to 95 percent efficiency.

Industries will be required to recycle more water. Golf courses, long a target of conservationists, must reduce their water use slightly, with new courses facing tougher restrictions, including limits on how much turf they can plant. And artificial lakes and swimming pools larger than Olympic size will be banned.

Homeowners will have to reduce their use of water by 6 percent during the first plan and more during later plans. Cuts will likely be spurred by increases in water rates. Officials hope that homeowners will replace their Edens with "mini-oases"—yards styled partly with grass and partly with desert plants—and that they will cover swimming pools to reduce evaporation and replace toilets with slow-flow systems using several gallons less per flush.

There are signs, which started to show even before the state added its legislative pressures, that the wasteful attitudes of the past are giving way. Since 1973, when city residents used about 200 gallons per person daily, the average water use has dropped by about a fifth.

The community erupted in 1982 when developers opened a huge swimming pool with machine-powered surf and a subdivision with 15 artificial lakes. In a stroke of hydrologic justice, neither project got off the ground. The wavepool, called Breakers of Tucson, didn't work and its owners filed for bankrupcy, although new owners have recently reopened it. The lake development ran out of money before a single house was sold. Today, standing deserted behind locked gates, the subdivision seems an anachronism, a symbol of a bygone era without limits.

Or is it?

Some people here are convinced that problems are well on the way toward solution. In fact, R.B. "Buck" O'Rielly, a politically powerful businessman and head of SAWARA, contends that Tucson doesn't have a water problem. He prefers to call it a "management resource challenge." But environmentalists are still worried. While they agree that laws and conservation campaigns may cut water consumption, they maintain that the water "saved" won't keep the desert from being taken over to house new arrivals.

Indeed, population growth may pose the biggest water problem of all. The Arizona Department of Water Resources estimates that urbanites will be the majority water users by 2025. However, the state's water law requires officials to fit the water supply to the expected population, not the other way around. Growth, the law assumes, is inevitable in this Sunbelt city. The law does require new subdividers to prove that their land has a dependable 100-year water supply. But legislators threw in a loophole big enough to drive a bulldozer through. For the next 20 years, anyone buying CAP water is presumed to have an assured 100-year supply.

This scenario may work better on paper than in real life, however. Under various laws and treaties, the Colorado River is committed to deliver 16.5 million acre-feet of water to seven Western states and Mexico. But its actual annual flow is estimated to be less than 15 million acre-feet. The problem for Arizona is that if there is a shortage, California gets its share of the water—4.4 million-acre feet—first.

But Wesley Steiner, head of the Arizona water resources agency, calls those who warn of CAP shortages "doomsayers." He reasons that a tight-fisted Congress will never appropriate the money for new water projects that would enable the upper basin states—New Mexico, Utah, Wyoming, and Colorado—to use all their allotted share of river water. That leaves plenty available for the CAP. He also contends that the reservoirs in the Colorado River basin will be able to bank enough water to handle any droughts.

Agriculture versus Population

Such optimism, however, could be melted by the "greenhouse effect"—a global increase in temperature and associated changes in precipitation that some scientists say will begin next century because of fossil-fuel burning today. In a study for the National Academy of Sciences, Roger Revelle and Paul Waggoner warned that such an effect could slash the Colorado River's flow by 40 percent.

Steiner calls the report "interesting but inconclusive." He notes that the report showed that temperatures in the Colorado River basin averaged 2 degrees higher from 1901 to 1930 than from 1931 to 1976—but the runoff was 20 percent greater during the early period as well. However, Revelle, a professor of science and public policy at the University of California at San Diego, cautioned in a recent interview that "you'd better abandon irrigated agriculture or abandon the idea of continued population growth."

If shortages do occur in the CAP, forsaking agriculture seems most likely. The state would probably buy farms around Tucson or along the Colorado to make up the gap. Another possibility is to use spreading basins and percolation ponds to shunt CAP water into the ground during years of abundance to save for droughts. This practice, called recharge, is used in southern California for trapping and storing rainfall and imported Colorado River water. As many as three demonstration recharge projects could begin here during the next decade, leading to full-scale recharge by the 1990s.

Beyond that, officials might have to turn to several as-yet-untested technologies for bringing in more water. These include cloud-seeding the mountains of the Colorado basin; water "harvesting," which uses cement ponds to store water that runs off streets and roofs; and building reservoirs along the streams to catch storm water before it runs away.

There are problems aplenty with these ideas. A recharge system could allow those who live "downstream" from the city water system—but who don't pay into it—to pump out expensively gained water for free. One proposed solution is to create a new metropolitan water agency, an idea that existing agencies not anxious to share their authority aren't welcoming with open arms.

Damming up stormwater or creating recharge ponds worries some flood-control engineers; they fear these practices could soak the ground and leave no breathing room during a big rain, which could mean larger floods than before. Studies in many California cities have revealed that there is often more lead in rainwater than drinking-water standards allow, which could force water harvesters to install treatment systems. And the notion that people might turn to their rooftops instead of taps for water strikes some authorities here as a bit unrealistic.

Beyond these ideas are the truly exotic ones, such as removing the salt from piped-in seawater or shipping icebergs from Antarctica to California, which would give its share of Colorado River water to Arizona in exchange. At one time, there was even talk among area officials of building a canal to bring in water from the Columbia River in the Pacific Northwest. But utter disgust among politicians and citizens in the Northwest prompted Congress to ban federal studies of such a canal until 1987.

Environmentalists prefer limiting population growth to what the area's local water supplies can support. One suggestion, for example, is to raise water rates so high that people won't want to move here, or that current residents will decide growth isn't worth the cost. But such controls seem unlikely.

For example, the Pima County Board of Supervisors, which controls zoning in most undeveloped areas, has a solid, pro-development majority, with many of its members receiving nearly two-thirds of their campaign contributions from home-builders. The board approved more than 9 of every 10 rezoning requests from mid-1980 through 1982. And at a 1981 hearing of the county planning commission, officials from city and state water agencies warned that even with the CAP, the area's water supplies could ultimately limit growth. However, Peter Hershberger, the commission chairman, who is now a state legislator, replied, "If we can put a man on the moon, we sure as hell can pump seawater over from the Gulf of California." Yet the U.S. Army Corps of Engineers had already determined that desalinizing seawater, along with processing water from icebergs, is too expensive to be feasible in the foreseeable future.

The other solutions being considered aren't cheap either. Although CAP water is now sold at a discount to encourage use, it will eventually cost Tucson more than twice the $40 an acre-foot it pays to pump groundwater. That doesn't include the cost of treating the bacteria-laden river water to meet health standards. Golf courses will pay $300 an acre-foot or more to use sewage effluent. And if Tucson ever follows Denver's route and recycles sewage effluent for drinking, that, too, would cost more than $300 an acre-foot.

Farmers will pay $1,000 to $1,500 an acre for drip irrigation, compared with $200 or less for conventional methods, according to an official with the U.S. Department of Agriculture's Water Conservation Laboratory in Phoenix. Today farmers use drip systems on less than 30,000 acres in the state, says Dale Bucks, an irrigation engineer at the lab. A laser-leveling system, he adds, costs up to $15,000 to install.

While it is hard to imagine Tucson ever running out of water, it isn't so hard to imagine the city someday running out of money. ☐

CALIFORNIA'S PERIPHERAL CANAL: SKIRTING THE DELTA — AND THE ISSUES?

by
Timothy Pfaff

If California actually builds its proposed peripheral canal—an enormous earthen ditch that would connect the vast river systems of Northern California with the complex water delivery systems in the parched southern portion of the state—its then-completed State Water Project (SWP) will be the largest public works project in world history. Unless, that is, the Department of Defense has achieved something even more massive by then. The MX missile system, as last proposed by the Carter administration, was in its time the only other public works project that might have topped the SWP, in terms of complexity, cost, and controversy. Many environmentalists think that the peripheral canal is like the MX in another important aspect: its virtually unquantifiable capacity for destruction.

At first it may seem difficult to understand how a single facility—and, in terms of hydraulics, a simple one at that—could provoke such controversy in a state that has far more dams than rivers, more wells than farms, more canals than Venice, and, overall, one of the most complex water delivery systems in the world, operated by agencies at every level of government. But the very fact that it would be a state facility is at the heart of the controversy. Increasingly more Californians are asking, Will the peripheral canal serve the state as a whole? And will it truly serve the state?

The peripheral canal is the central feature of California's Senate Bill (SB) 200, legislation which also authorizes the eventual construction of additional water storage and power-generating facilities for the SWP. The bill was signed into law by Governor Brown on July 18, 1980—not without fanfare. It was

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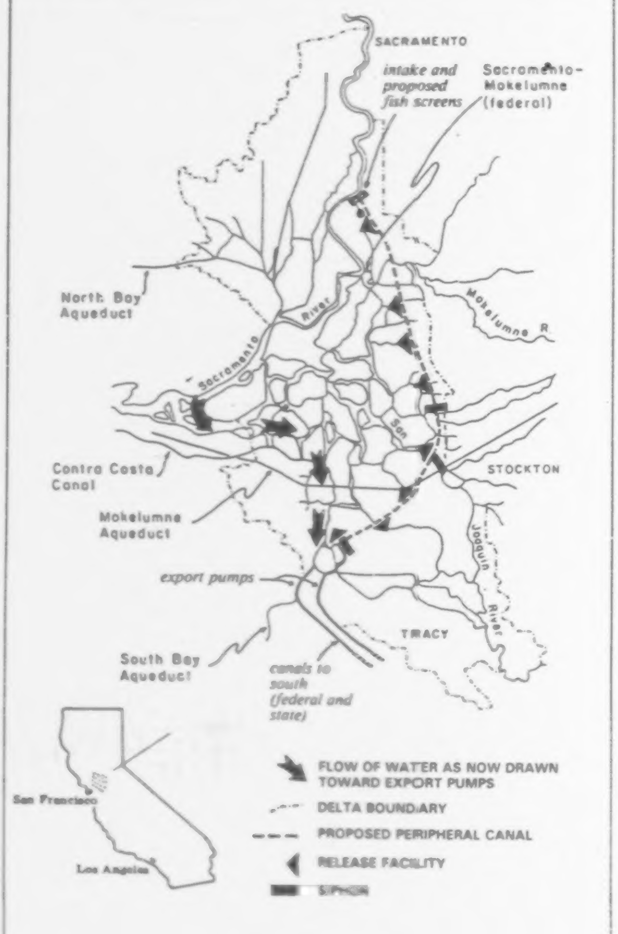

The proposed peripheral canal would link northern California rivers with the California Aqueduct, the south's longest water delivery system, by skirting the Sacramento-San Joaquin Rivers Delta. Varying between 300 and 400 feet in width, the 43-mile-long elevated canal would block all but four of the channels it crosses, cutting off the water sources for about 200,000 acres (one third) of Delta lands. More than 500,000 acres of prime farm land are found in the Delta region, 6,000 acres of which would be eliminated by the canal, and another 20,000 acres of which canal opponents claim would be threatened by flooding or seepage from the canal. Proponents of the canal have argued that it is not reasonable to use Delta water for agriculture in the region. Water quality in the southern Delta has already deteriorated due to diversion of seasonal flows by the existing aqueduct.

On previous page:
The California Aqueduct, "backbone" of the State Water Project, carries water from the Delta south through the San Joaquin Valley, ending its 450-mile course near Los Angeles.

deemed that the actual signing, pen across paper, merited live television coverage from Los Angeles, where the event took place. The occasion also called for a carefully measured speech by the governor, extolling the importance of "unity and interdependence" among Californians. Soon afterwards, opponents of the measure collected enough signatures statewide to qualify it for a referendum, the first in California since 1952. That referendum measure now will go before a popular vote as Proposition 9 in a state ballot on June 8.

It startled some and outraged most environmentalists that the man signing SB 200 was the same governor who had repeatedly expressed genuine concern for the California environment—and who had begun his administration under the celebrated slogan of "less is more." Now, in addition to environmentalists, farmers, taxpayers, and power and water ratepayers statewide are becoming alarmed at the thought of a facility whose price tag is currently estimated at more than $1 billion. Furthermore, the issue is resurfacing at a time when the state's legacy of budgetary brinksmanship has left it with a "revenue shortfall"—in simpler terms, the inability to pay its 1982 bills.

Vascular Surgery?

The issue is indeed complex and needs to be viewed from many perspectives, perhaps the most fundamental of which is an overview of the state's geography and hydrology.[1] Northern California—in this case the area from the Oregon border south to a line from the San Francisco Bay on the coast to Yosemite National Park near the Nevada border—receives the greater share of the state's rainfall and snowmelt and consequently has its largest, least developed, and most important rivers. In fact, rivers north of San Francisco carry about 80 percent of the state's water runoff, the Sacramento and San Joaquin rivers alone bearing about 40 percent of it.[2] Northern California also has the SWP's single largest water storage facility, Oroville Dam.

The southern portion of the state, however, has the greater share of the state's arable farmland and a large majority of its people. Southern California also has an essentially arid climate and virtually no major water resources of its own at this point.

In the state's great Central Valley lies a formidable, if sunken, barrier between the "two Californias": the Sacramento-San Joaquin Rivers Delta, lying just between the Bay Area and the Sierra Nevada. The main obstacle to sending water from the north downstate, the Delta is the largest inland waterway of its kind in the nation outside Alaska. It is a tangle of 1,100 miles of serpentine but navigable channels that collect water from the great northern rivers and, eventually, release that water into the Pacific Ocean via the San Francisco Bay, to which the Delta is directly connected.

The two largest water delivery systems in the state, the SWP and the federal Central Valley Project (CVP), both draw their water–some 5-6 million acre-feet (MAF)[3] of it a year–from the south end of the Delta. But both the geographical complexities and the seasonal variables of Delta hydrology limit the amount of water that can be pumped out of the Delta at any one time, and particularly in summer, when riverflow is at its lowest. Because the Delta meets the ocean at the Golden Gate, its water is a unique blend of fresh- and salt-water systems; it is perpetually vulnerable to salt-water encroachment, which is as undesirable to water exporters as it is to residents and farmers of the Delta and Bay.

Since the State Water Plan was undertaken in the late 1950s, California's water developers have envisioned some kind of "Delta transfer facility," to obviate the problems posed by the troublesome–and troubled–Delta. Various plans for direct but unimaginably destructive "cross-Delta facilities" have been passed over in favor of the peripheral canal, so named because it would skirt the Delta at its eastern and southern edges. From a mile-long intake near the town of Hood, the canal would directly link the Sacramento River with the SWP's California Aqueduct, the 450-mile-long tributary that begins its southward course at the enormous pumping plant near the south-Delta town of Tracy. It is easy to see why developers have called the canal "the missing link" in the SWP: in one smooth trough it would link the north's greatest river with the south's longest conduit.

The metaphor of vascular surgery comes to mind. An artificial vessel is introduced to join functional, free-flowing tributaries while simultaneously shunting a choked or tangled passage that impedes flow between the two. The metaphor holds in that the Delta is an unstable and, currently, unhealthy passage that could profit by being by-passed, to the double advantage of water exporters and its own, already compromised well-being. And canal construction, like vascular surgery, would be a delicate, long, and costly task.

But the metaphor then breaks down. Most vascular surgery is microsurgery, and the peripheral canal is anything but small. As designed for SB 200, it would be 43 miles long, 400 feet (42 freeway lanes) wide, and 30 feet deep. An unlined dirt structure, it would, state engineers say, soon seal itself with Sacramento River silt. From the standpoint of today's technology, it is remarkably simple. Ronald B. Robie, director of California's Department of Water Resources (DWR), says that as an engineering project, "It's just a big ditch."[4] Environmentalists and other project opponents hope that the canal will not be California's last ditch.

Delta Problems

At its proposed size the canal would have an annual capacity of 16.3 MAF of water; at peak operating levels it could divert as much as 70 percent of the Sacramento River's average flow.

From the beginning environmentalists have expressed concern about the effects such a diversion would have on water quality in the Delta and Bay. Without the great rushes of water from winter and spring floods, both areas are prey to salt-water encroachment, pollutant buildup, and stagnation. Particularly hard hit would be the South Bay, below the Bay Bridge, a heavily industrial area that relies for its water quality on the "flushing flows" of circulating fresh water from peak runoff.

Michael Storper,[5] a geographer at the University of California, Berkeley and a legislative advocate for Friends of the Earth, explains the danger: "When the fresh water level falls below a certain threshold, the river water goes out the Golden Gate and doesn't flush the south two-thirds of the Bay. The peripheral canal is designed to take precisely that peak flow. It takes water out of the Sacramento River before it even reaches the Delta. It's so big because it's designed to take the peak flood." His is not a "what if" fear. Only recently was the San Francisco Bay, still one of the most desirable metropolitan areas in the world, declared "recovered" from the disastrous 1960s, when a deadly combination of drought and unchecked pollution wreaked havoc with the Bay ecosystem, killing off many varieties of wildlife and leaving a stench detectable six miles inland.

DWR Director Robie refutes Storper's contention that the canal could greatly diminish those flushing flows, because, he says, "the canal is just a canal." Pointing out that "the whole issue is terribly confused," Robie adds: "The flushing flows could, however, be captured by upstream reservoirs—but there has been very little concern about those reservoirs. Someday there will be application to the state to build the upstream reservoirs—they're in SB 200—and the applications will come before the Water Control Board, which will have to decide how much water is permitted to be stored in those dams and how much is permitted to run uncontrolled."

Even without the canal, Delta conditions are deteriorating. "Pumping water out of the Delta has distorted its flow patterns," Storper says, "virtually deci-

SWP: ONE LINK IN THE CHAIN

The State Water Project (SWP) is one link in the chain of water projects that began when the Spanish built aqueducts and dams to serve their early day missions and settlements. A long drought that began in 1928 spurred the legislature to pass the State Central Valley Act in 1933. In that depression time, however, the state could not finance the project, and much of the water development which that act authorized was accomplished by the federal Central Valley Project, beginning with the CVP's water service to Contra Costa County in 1940.

In 1951, the California state legislature authorized what is now the State Water Project. In addition to water storage and distribution, the project was conceived and planned with recreation and fish and wildlife enhancement among its major purposes. In 1959, the legislature passed the Burns-Porter Act, which provided the major financing for the project's initial facilities. In 1960, the voters of California approved a $1.75 billion bond issue under Burns-Porter to begin to build the project's dams, reservoirs and aqueducts. The Department of Water Resources, which designed, built, and operates the project, has also issued revenue bonds to finance certain features of the project, such as hydroelectric plants.

Initial facilities of the project, completed in 1973, include 18 reservoirs, 15 pumping plants, 5 power plants, and 540 miles of aqueduct. Parts of the project have been serving Californians since 1962. Surplus water from the Feather River watershed and the Sacramento-San Joaquin River Delta is caputred and transferred to "areas of need," from the San Francisco Bay area to the San Joaquin Valley and Southern California. The project is to reach its full delivery capacity, 4.23 million acre-feet (MAF), sometime after the year 2010. To help deliver that quantity of water, the Department of Water Resources has proposed a system of ground water storage, additional reservoirs, the peripheral canal around the Sacramento-San Joaquin Delta, other water transportation facilities, and programs of water conservation and waste water reclamation.

The project begins with three small lakes on Feather River tributaries in Plumas County, high in the Sierra Nevada Mountains. The lakes—Lake Davis, Frenchman, and Antelope Lakes—are devoted primarily to recreation. Near the town of Oroville in Butte County, the branches and forks of the Feather River flow into Lake Oroville, the project's principal reservoir. From this reservoir, the released water flows through the two powerplants of the Oroville complex and the natural channels of the Feather and Sacramento rivers to the Delta.

In the north Delta, the North Bay Aqueduct supplies water to Napa County and eventually will carry water to Solano County as well. In the south Delta near Byron, the Delta Pumping Plant lifts water into Bethany Reservoir. From this small reservoir, some water is lifted again by the South Bay Pumping Plant into the Sough Bay Aqueduct, which serves Alameda and Santa Clara counties.

Most of the water flows from Bethany Reservoir to the California Aqueduct, which winds along the west side of the San Joaquin Valley to San Luis Reservoir, a 2.04 MAF reservoir built and operated jointly by the state Department of Water Resources and the federal Bureau of Reclamation.

Water from either San Luis or the Delta flows south down the valley, and is raised another 969 feet by four more pumping plants before reaching the foot of the Tehachapi Mountains and then Southern California. In the lower San Joaquin Valley, a short branch aqueduct serves agricultural areas to the west. In the 1980s, this branch may be extended to serve Santa Barbara and San Luis Obispo counties.

On the main aqueduct at the Tehachapis, the A.D. Edmonston Pumping Plant raises the water 1,926 feet in a single lift to enter 10 miles of tunnels and siphons. From this Tehachapi Crossing, the water flows into the Antelope Valley. The aqueduct divides here. The east branch carries water through the Antelope Valley and into Silverwood Lake in the San Bernardino Mountains. From Silverwood, the water enters the San Bernardino Tunnel and drops 1,418 feet into the Devil Canyon Powerplant. Then the water flows in a buried pipeline to Lake Perris, southernmost terminus of the project, southeast of Riverside and 444 miles from the Delta where the aqueduct began.

Water in the West Branch flows into Pyramid Lake in Los Angeles County, through the Angeles Tunnel, into the Castaic Powerplant, then into Castaic Lake, terminus of the West Branch.

SOURCE: California Department of Water Resources, "The California State Water Project," Sacramento, 1979.

mating the fish and wildlife populations in the area." State officials agree that water exports have changed the Delta's flow patterns and seriously weakened the levees that keep Delta waters out of its below-sea-level islands. "For years," Robie says, "everyone has known that the present method (of water exportation) is unacceptable, from an environmental or a technical point of view."

Threat to Fisheries

Conditions in the Delta have become the rallying cry in DWR's campaign for the canal. The official response to any objections to building the canal is some form of the message that the canal is needed to protect the Delta. Robie says, "The present method of transferring the water through the Delta is ruining the Delta's fisheries." It has created a condition called "reverse flow." Confused by that flow, anadromous fish (which live in the ocean but spawn in rivers) swim toward or are simply sucked into the powerful pumps that send water—as well as fish, eggs, and fry by the multi-millions—into the CVP's Delta-Mendota Canal and the SWP's California Aqueduct.

DWR officials claim that the canal would solve the problem of reverse flow, but environmentalists like Storper caution that such hope "may be premature. We don't yet know enough about the Delta to change its plumbing in that radical a fashion," he says. "And of course the change would be irreversible. It's inconceivable that a facility costing such a vast sum would not be used, regardless of its future consequences." San Francisco environmentalist Gray Brechin calls the canal, as a solution to the problem of reverse flow, a "colossal technological bandaid."[6]

Both recreational and commercial fishermen have long opposed the water projects that pose so great a menace to the important fish populations of the Delta and Bay. To a large degree, the concern about fish has come to represent the larger concerns about the effects of water projects on all forms of wildlife in the area. Even so, available fish statistics are telling. California Department of Fish and Game figures indicate declines of 70 percent in populations of adult striped bass and 65 percent in adult salmon since 1972. One reason for the decline is plainly visible. *San Francisco Examiner* sports writer Tom Stienstra cites the example of striped bass, which he says are being sucked "downstream" at the rate of some 70 million per year. He adds that they now are teeming in the San Luis Reservoir, below the pumps, "like a can of sardines."

Both state officials and canal opponents have focused on the issue of an effective fish screen. SB 200 requires that one be in place before the canal is put into operation. But even though it has spent nearly $100 million on the project so far, the state has yet been unable to build workable screens for its present facilities. Robie sees the current lack of a working screen as a poor reason not to build the canal. "The fish screen has not been built because the canal has not been built," he says. The state has plans for screens with 5/16-inch and 5/32-inch holes, which, he adds, "nothing can go through." He also says that the mile-long entrance to the canal allows for an off-river channel "to get the water going very slowly before it enters the canal, to make the fish screen work. The entrance to the canal is going to be very big, and the screens are going to be expensive, but we don't think there is any problem with making them work." Others, like Storper, say, "Seeing is believing."

Immediate Consequences

It is an increasingly conspicuous irony that for all of the concern about long-term environmental issues, relatively little has been said about the direct and immediate effects the canal would have on the Delta. Alex Hildebrand,[7] a registered engineer, Delta farmer, and director of the South Delta Water Agency, notes that it would be built on–and therefore eliminate–6,000 acres of prime Delta farmland. It also would threaten the 20,000 acres surrounding it with destruction by seepage or flooding from the canal. (The canal would be raised, making its water level a full ten feet above that of the Delta channels around it.)

The canal would cut off all but four of the channels it crosses and would be an enormous physical barrier between the central Delta and the 100 miles of channels and 200,000 acres of Delta land south and east of the proposed canal. Furthermore, none of the Delta protections written into the pertinent laws would apply to that outlying third of the Delta. Perhaps most ironic of all is the fact that the Delta is one of the last areas in the state where family farms still survive.

Hildebrand calls DWR's argument that the canal is to protect the Delta "a deceptive facade." In truth there is little reason to doubt the sincerity of the state's or environmentalists' concerns about present or future Delta conditions. But neither is there reason to regard the SWP as a kind of Delta Benevolent Society. The peripheral canal is not being built to save the Delta. Like other SWP facilities before it and to come, the canal *is* being built to transport water from Northern California to the parched southland. If the Delta were "fixed" in the process, no one would protest its repair. But it is easy to discern that protection of the Delta is clearly a secondary gain. Recent bills in the state legislature would authorize the expenditure of some $250 million for long-overdue and sorely needed restoration of Delta levees. But, tellingly, there is a contingency: the laws would go into effect only if SB 200 survives the referendum vote and construction of the canal is authorized. On the surface, the measure seems a kind of tradeoff, but beneath the surface may be a yet more revealing realization: that a healthier, more resilient Delta would mean a more secure, consistently operational canal.

"A Loaded Gun"

A number of environmental protections are written into SB 200 and pertinent legislation. There are provisions for the maintenance of fish and wildlife populations at "historical" levels and others for "reasonable" standards of water quality in both the Delta and the Bay. And a voter-passed Proposition 8, which would take effect if SB 200 passes and is enacted, protects California's north coast rivers by designating them a part of the state's "wild and scenic" system. That designation means they could not be developed without the proposed development going before a popular vote. (Proposition 8 also writes the maintenance of Delta water quality standards into the state constitution.)

Robie says such legislative safeguards offer the best environmental safeguards because they can't be changed without a two-thirds majority of a popular vote. Storper has reservations about the power of such laws. He explains: "The law says that at some future time, the two directors of the Department of Fish and Game and the Department of Water Resources will sit down and make an agreement about the standards necessary to protect the Delta. The problem is that there is no public review of that agreement. Both directors work for the same boss, the governor, and that's like the right hand siding with the left. There's no adversary relationship that might result in an agreement that would represent everyone concerned. Instead it will represent what the governor at that time wants. That's one of our big fears: the building of a permanent facility in a changing political climate.

"Once a facility like the canal is in place, laws governing its use are much more easily changed and compromised. That's an inherently dangerous situation. I think that the people in the state government who support the canal are sincere about wanting to protect the environment, but to my mind they have a naive understanding of the history of this issue and of the capacity of legal procedures to make sure that the project is operated properly. The peripheral canal has an enormous potential to destroy the Delta and the Bay if it is operated improperly." Robie calls such thinking "paranoid."

The ultimate safety of the state's undeveloped northern (and particularly north coast) rivers remains a lingering concern for many. A state legislator once called the canal "a loaded gun pointed at the north coast rivers," and William Sweeney, an official of the U.S. Fish and Wildlife Survey during the Carter administration, remarked that the beginning of canal construction would be "the day you can say goodbye to the upper Sacramento and Eel rivers."[8] One thing is clear: direct access to the Sacramento River would mean ready access to those undeveloped rivers.

It is no secret that the state's water interests have been eyeing those rivers from the beginning, and many developers, it now seems, actually see the canal as a liability if they are forbidden access to the rivers. After state voters passed Proposition 8 protecting those "wild and scenic" rivers, factions within the state's agricultural organizations, which were once in clear support of the canal, suddenly withdrew that support. In the final days of the Carter administration, the governor and other state officials petitioned the Department of Interior for wilderness status ("real protection," environmentalists think—or once thought) for the north coast rivers and got it. Spokesmen for the powerful Metropolitan Water District (MWD) of Southern California, the single largest importer of water from the north, expressed patent displeasure with the governor for that move, which, they said, came "out of the blue." MWD sent a full-time lobby to Washington to block the designation. The wilderness status is being contested today.

North versus South?

The story of the taming and harnessing of water in the West is a history of internecine strife and political civil wars, fought along regional and factional lines. From the beginning the battle over the canal has been construed, by various factions and for many reasons, as a confrontation between Northern and Southern California. Northerners have, naïvely but perhaps understandably, deplored the loss of "their" water. But curiously, the southern factions have often been more vitriolic in their criticism of northern attitudes. A spokesman for the J. G. Boswell Company, the largest cotton grower in the world and one of the largest corporate farming operations in the nation, has denounced SB 200 as "an illusory bill" that does not guarantee increased water deliveries to the south. The bill, he says, "subordinates people and agriculture to fish and wildlife in Northern California."[9] People who oppose the canal for environmental reasons, however, are eager to drop the north/south sentiment. "It's a matter of all the people, certainly all the urban people of the state, getting ripped off by agriculture," Storper maintains. "The simple fact of the matter is that agriculture uses 85 percent of the developed water in California."

For decades, economist Paul Shuster Taylor, an emeritus professor at UC Berkeley, has argued convincingly that the SWP was created to promote continued land speculation by the sidestepping of a federal law opposing subsidies of federal water for corporate landholdings.[10] The federal government's Central Valley Project was made possible through the Reclamation Act of 1902, a law created to protect family farms.

The law was explicit about providing subsidized water in an amount sufficient to irrigate just 160 acres of land per resident farmer.

In the 1940s, it appeared that this 160-acre limitation might, for the first time, be enforced. Owners of large landholdings in the Central Valley immediately petitioned the federal government for exemption from the acreage limitation. They were turned down.

In a 1946 letter to the *San Francisco News*, then-Secretary of the Interior Harold I. Ickes explained: "It is the age-old battle of who is to cash in on the unearned increment in land values created by a public investment. . . . The limitation provides for the distribution of the benefits of great irrigation projects among the many and . . . prevents speculation in lands by the few."[11] Still, the U.S. Bureau of Reclamation's continued disinclination to enforce the 160-acre limitation virtually promoted continued land speculation. Southern California landowners, in any case, turned to the state. Perhaps predictably, the SWP package that was authorized in 1960 included no acreage limitation at all.

With irrigation, lands in the parched valley, once bought cheap, have increased in value by as much as 1,000 to 1,400 percent, and massive amounts of SWP water have gone to support that growth. The Metropolitan Water District, the greatest buyer and wholesaler of SWP water, serves some 12 million people through 27 Southern California water agencies to whom it sells water. After it has met those obligations, the MWD sells its "surplus" water to Kern County growers, often for as little as one-seventh of the retail price. The practice has been called "welfare for the rich" and prompts critics like Storper to point out that conflict in California water politics is not really north vs. south, but rather agricultural and real estate interests vs. urban concerns or, more fundamentally, "the rich vs. the rest of the people of the state."

Division of Waters

One of MWD's own board members, Robert Gottlieb of Santa Monica, has documented the Met's practice of selling off its surplus water.[12] Using a 1981 report by the California Institute for Rural Studies, Gottlieb contends that as much as 40 percent of SWP water goes to the following eight landholders in Kern and Kings counties: Chevron U.S.A. Inc. (37,793 acres); Tejon Ranch Company (35,897 acres); Getty Oil Company (35,384 acres); Shell Oil Company (31,995 acres); McCarthy Joint Venture A (25,105 acres); Blackwell Land Company (24,663 acres); Tenneco West, Inc. (20,180 acres); and Southern Pacific Land Company (16,528 acres). Gottlieb further claims that those eight landholders control 74 percent of the vineyards, 71 percent of the orchards, 54 percent of the row crops, 72 percent of the grazing crops, and 54 percent of the as-yet undeveloped land in the area receiving MWD surplus water.

The MWD prefers to talk of "contracts" and "entitlements," rather than "surplus." When the SWP was created, the districts and agencies it serves made long-term contracts for water deliveries—contracts that often are enormously inflated, some of them having been based on estimates that the population of California would reach 56 million by the year 2020. Today that figure seems as unlikely as it would be undesirable. But the alarm is still sounding. In its push for the canal, MWD is telling its ratepayers that the facility is more urgently needed than ever, since in 1985 Arizona will be allowed to take more water from the Colorado River, which also serves the MWD and Southern California. The MWD says that it will sustain a "maximum loss of entitlement of 700,000 acre-feet annually."[13] In a state assembly hearing, Gottlieb cited a MWD staff report which noted that the above-stated loss translates to just 240,000 acre-feet even in dry years, since the MWD never has used its full entitlement of Colorado River water. The Met is also quiet about the fact that it has not in the past used and will not in the foreseeable future use all the SWP water to which it is entitled.

Even though the contracts that are in effect are ones which could not possibly have been met by the SWP without some kind of Delta transfer facility, contracts are contracts. Now adding to that confusion is the consideration that the federal Water and Power Resources Service, formerly the Bureau of Reclamation, has expressed its interests in a partnership in the proposed canal—primarily so that it can incur some *new* contractual obligations. Meanwhile, Southern Californians are being told that without the peripheral canal, "[they] are going to turn on their taps and nothing may come out."[14]

In an Institute of Governmental Studies Public Affairs Report,[15] Storper and Richard Walker, an assistant professor of geography at UC Berkeley, addressed the issue in a single, disarming sentence: "The need for additional surface water has not been clearly demonstrated." Since that 1979 report, Storper *has* demonstrated that the MWD could meet its estimated demand for water through the year 2000 *with existing facilities*, given two things: a 15 percent conservation in the use of agricultural water (a figure DWR considers reasonable) and some wastewater reclamation (which both the MWD and DWR agree is practical and cost efficient). Storper adds: "A 5 percent conservation by agriculture, which could easily be achieved with existing technology, would increase the supply available to urban areas by 33 percent."

A major problem with SB 200, environmentalists say, is that it contains no specific conservation measures beyond the maintenance of "reasonable" water quality standards. DWR director Robie concedes that "there are a lot more efficient ways that we can use water in the valley." He proposes more efficient irrigation devices, like sprinklers and more water-efficient furrow irrigation methods—and "reducing the use of water." Still, Storper says, "subsidies discourage efficiency."

Others have gone farther, saying that subsidies promote waste. Last December the DWR made an investigation of the complaints of an Imperial Valley farmer, who charged that he was being forced to build dikes to keep water from the Salton Sea—a huge saltwater lake in southwestern California that would normally be desert—from flooding his farm. (His has not been the only such complaint. There have been other reports of great "dumps" of Imperial

Valley water, some of which, it is alleged, have flooded parts of Mexico.) DWR officials learned that the district, which relies on Colorado River water, was losing more than 900,000 acre-feet of water per year, from a combination of spillage from overflowing canals, seepage through unlined canals, and other forms of inefficient irrigation.[16]

Who Pays?

If conservation and wastewater reclamation would obviate the need for more facilities, it would seem difficult to justify the phenomenal expense of building the various facilities in SB 200. DWR estimates that the peripheral canal alone would cost about $1.3 billion by the time it would be completed. Their long-range "guesstimate" of the price for the complete SB 200 package by the year 2000 is about $10 billion.[17]

What's more, the costs of the facilities are only a beginning. It takes a tremendous—and continual—supply of electricity to transport water within California. The map on the wall may seem to say that California water, left to its own devices, would head straight for Mexico by the force of gravity. In actuality, its southward path is uphill. Water in the California Aqueduct is "lifted" a number of times on its route—the last time nearly 2,000 feet over the Tehachapi Mountains north of Los Angeles. As a result, the SWP is the single largest user of electrical power in the state.

The project was conceived in a day when electricity was, in the words of one power company's jingle, "penny cheap." Oil to produce it cost $2 a barrel. Today, of course, electricity is costly, and an enlarged SWP would have incrementally larger fuel bills—starting with the tab for lifting the Sacramento River water that first ten feet into the canal. And then there would be the need for more energy at every pump along the way, to move the additional water.

Ratepayers who learn of the water subsidies soon realize that someone is paying the full price. Taxpayers, and urban Southern Californians in particular, are becoming increasingly aware of the burden those subsidies place on them. Tom Brick, a Southern California coordinator for Californians for a Fair Water Policy, says, "Southern Californians have three very good reasons to oppose Senate Bill 200. We don't need it. We can't afford it, and we won't get the water anyway. . . . In some parts of the state, [agriculture is] getting water for $3 to $5 an acre, while we're paying $150 to $200 an acre in urban Southern California."[18] As just one example, Los Angeles taxpayers have paid for nearly one-third of the water MWD has contracted for and received about 2 percent of it. Southern California ratepayers pay for the water they receive from the SWP, while taxpayers statewide pay, directly and indirectly, for the facilities used to transport that water.

When legislation to create the SWP was being brought to the attention of California's electorate in the late 1950s, voters were told a number of things. The official voters guide to that election asserted the following about the proposed SWP: "The project will not be a burden on the taxpayer; no new state taxes are involved; the bonds are repaid through the sale of water and power. In other words, *it will pay for itself*" (Original emphasis). The voters also were told that additional water was badly needed to correct the serious "groundwater overdraft" caused by the heavy use of well water to irrigate fields—a situation that persists to this day. Voters were told imported water would replenish the subterranean supplies.

"It never quite works the way the developers say that it will," Storper explains. "The State Water Project itself is a good example. Nearly all the water obtained through it has gone to develop new lands. Less than 10 percent of it has gone to land developed prior to 1959, when it was presented to the public for approval. It has proved to be a pattern for landowners in the south: they take the water and expand onto new land. There are no controls on the development of land in the Central Valley, and there still are hundreds of thousands of undeveloped acres."

Robie recognizes the problem of groundwater overdraft and says that he has long supported Governor Brown's Water Rights Commission, which in 1979 proposed the creation of management districts in each of the overdrafted basins. "It's something that has to be done on a case-to-case basis," he says. "The State Water Project and SB 200 are not going to provide the new water necessary to rescue the valley. The water we bring in is not new water; it is just maintaining existing supplies. The only alternative is to go to better management of existing supplies." The commission recommended that mandatory groundwater management be part of SB 200, but it was not part of the bill as finally passed and signed. "The legislature did not choose to put it all in one bill," Robie explains.

"The groundwater controls we are advocating really would be in the interest of agriculture," Storper continues. "But what we have encountered is a hands-off, anti-regulation attitude. There's still a lot of speculative gain to be made, and these people want to be subsidized without being regulated."

"The land in the valley is, for the most part, a sandy, gravelly aquifer. When groundwater is sucked out, the soil begins to subside and finally compacts. Then it never gets its water storage capacity back, and at that point, it's ruined completely and permanently. We already have the example of the Owens Valley and some lands in Kern County, but the problem is moving up the valley. There are already some lands in the southern San Joaquin Valley that have gone out of production. That's exactly what happened in the Tigres-Euphrates Valley. This is no joke: it's a Mesopotamia phenomenon repeating itself."

The Owens Valley, to which Storper refers, was one of the richest and greenest regions in the state in the last century. In the 1930s and 1940s it was turned into a dust bowl by ever-increasing diversion of the valley's water supply into the Owens Valley-Los Angeles Aqueduct, which still supplies water for municipal Los Angeles.[19] Could the vast Central Valley, the heart of the state and one of the most productive agricultural areas in the world, meet the same fate? The question is seldom asked in the press of more urgent issues.

"By Hook or Crook"

The present clamor for the peripheral canal is hardly a new phenomenon. In 1966 William E. Warne, then-director of the DWR, told the *Sacramento Bee*, "We need to have the peripheral canal in operation by 1974. Our water quality objectives could not be met during periods of subnormal runoff after then if the canal is not in operation. The canal is needed at the earliest date to prevent further damage to the Delta fishery."[20] The urgency—and the stated reasons for it—are the same today.

There is already great interest in the referendum vote in June, and countless more millions of dollars will go into campaigns on both sides of the issue. But while the returns will clearly be important, there is little reason to believe that the final verdict will be punched out in the ballot booths. There are indications that the canal and other SB 200 facilities are already underway—in both planning and actual construction.

In January, a DWR official announced that the state could go ahead with the canal, no matter what the final vote. Charles R. Shoemaker, a deputy director of the DWR, told a task force on the canal formed by Lt. Gov. Mike Curb that the language the voters approved for the project in 1960 names a "facility" to transport water through the Delta—and that that was authorization enough for the peripheral canal. He added that if bonds to finance the canal could not be sold, because they would be at a higher rate than the state allows, then the canal project could be financed on a "pay-as-you-go" basis by selling the water it would carry.[21]

The matter will probably be decided in the courts. Forces on both sides of the issue have promised litigation if their interests are not confirmed in the June election. For canal opponents, the greatest ally may turn out to be a commodity as valuable, and as hard to quantify in value, as water itself: namely, time. Inflation promises to drive up construction costs for every day that SB 200 is in court, and costs could conceivably soar out of reach.

It is equally clear that if SB 200 fails, on ballot or bench, the battle for a "Delta transfer facility" will by no means be over. The governor may extol the virtues of interdependence, but California's water power is not all located in Sacramento. It is a matter of record that Earle C. Blais, chairman of the MWD, told his board last year, "We'll get our water by hook or crook."[22] Cheaper—and environmentally far more brutal—proposals for getting water through the Delta have been made before, and, if necessary, they will be made again. A chilling thought for some environmentalists is that Governor Brown, knowing the state's water lobby as he surely must, may have been entirely sincere in saying that SB 200 is the best compromise possible for a facility that is destined to be. In any case, the state's only real hope is for intelligent management of its already stretched resources. California could afford to run out of gold. The same will never be true of water.

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PHOTO CREDITS
All photographs provided by the California State Department of Water Resources, Sacramento, California.

NOTES

1. For an in-depth overview of this subject, see William L. Kahrl, project director and editor, The California Water Atlas, State of California, 1979. The book contains detailed maps and charts, historical and contemporary NASA U-2 photography, detailed information, and histories and analyses of major events and issues in California water history.

2. Michael Storper and Richard Walker, "The California Water System: Another Round of Expansion?" Public Affairs Report, Institute

of Governmental Studies, University of California, Berkeley, Vol. 20, No. 2, April 1975, p. 8.

3. An acre-foot of water is the amount it would take to cover one acre of land with water one foot deep, or 325,000 gallons.

4. Mr. Robie's comments come from an interview conducted by the author in the director's office in Sacramento on October 27, 1980, for an article for California Monthly.

5. Mr. Storper's comments are from an interview conducted by the author in Mr. Storper's office in Berkeley on October 21, 1980, for an article for California Monthly.

6. Gray A. Brechin, "Small Promises, Big Threat To San Francisco's Bay," Defenders, Vol. 55, No. 4, August 1980, p. 204.

7. Mr. Hildebrand's remarks are taken from a transcript of a talk given to the Berkeley Rotary Club on December 3, 1980.

8. George L. Baker and Tom DeVries, "Water: What We Don't Know and Why We Don't Know It," New West, Vol. 5, No. 12, June 16, 1980, p. 42.

9. John D. Cox, "Canal Backers Fail To Budge Farmers," Sacramento Bee, December 8, 1981.

10. Professor Taylor's essays are indispensable reading for anyone who wishes to understand land and water politics from a political and historical perspective. His essay on the California Water Project for the Ecology Law Quarterly, Vol. 5, No. 1, Berkeley, 1975, is the definitive treatment of the creation of the SWP. In 1979, Arno Press, A New York Times Company, published his collected writings under the title Essays on Land, Water and the Law by Paul S. Taylor.

11. San Francisco News, October 31, 1945; Also quoted in Taylor, Ecology Law Quarterly, note 10 above, p. 14.

12. Gail Montgomery, "Peripheral Canal: Foes Launch L. A. Drive," Oakland Tribune, December 6, 1981.

13. Ibid.

14. Statement made by Lt. Gov. Mike Curb, a Southern Californian who was at the time a canal proponent. He has since switched his stand, arguing that the canal is too expensive.

15. Storper and Walker, note 2 above, p. 5.

16. Vic Pollard, "Salton Sea complaint probe adds to Peripheral Canal debate," Oakland Tribune, December 16, 1981; and "Wasted Imperial Valley water is ammunition for canal foes," Oakland Tribune, December 20, 1981.

17. Daniel J. Blackburn, "The Farm Bureau's big switch on the big ditch," California Journal, May 1981, Vol. 12, No. 3, p. 89.

18. "New water group in statewide drive against Peripheral Canal," San Francisco Examiner, January 12, 1981.

19. The story of the Owens Valley-Los Angeles water controversy is told in detail by Abraham Hoffman in Vision or Villainy: Origins of the Owens Valley-Los Angeles Water Controversy, Texas A&M University Press, 1981.

20. "State Agency Seeks Control Of Delta," Sacramento Bee, July 19, 1966.

21. Jim Dufer, "Official Says High Bond Prices, Negative Vote Need Not Deter Canal," Sacramento Bee, January 7, 1982.

22. George L. Baker, "Canal Politics Forge Strange Bedfellows," Sacramento Bee, March 26, 1981.

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Los Angeles Times

Water Still Divides California

The Split Is Purely Regional

By William Endicott

SACRAMENTO

There is a fundamental truth about water in California: Northerners have it; southerners want it. The result is a seemingly endless pitched battle between the forces of good and evil about how to get it from where they have it to where they don't. Who's good and who's evil depends on where one lives.

A reporter who recently moved from Los Angeles to Sacramento said he was amazed by the emotionalism that talk of water provokes in the north. He said everybody from his local pharmacist to the checkout clerk at the grocery store has an opinion—usually a strong one—on the issue. A northerner mentions favoring more water for the south at his or her own peril.

Indeed, water divides California along regional lines and cuts across party boundaries like no other single issue. Republicans and Democrats who figure each other for philosophical and/or political dolts on most things find a common, if parochial, ground when it comes to water. One begins to wonder if it is an issue that can ever be resolved.

The latest plan to go down the drain—if you'll pardon the expression—was devised by Republican Gov. George Deukmejian as an alternative to the voter-rejected Peripheral Canal, a key but still unbuilt element of the mammoth California Water Project. The Deukmejian plan would have moved water north to south by widening and adding to existing channels through the Sacramento-San Joaquin Delta.

Caught up in both the politics of an election year and the historic north-south differences over the question of transporting water from one region to another, it was scuttled by legislators last week after the senator carrying the plan for the governor, Democrat Reuben Ayala of Chino, said he simply did not have the votes to win its passage.

A paradox in its defeat is that some Southern California legislators who normally vote as a matter of course for any proposal to ship more water south opposed the Deukmejian plan for a variety of reasons, ranging from lack of environmental protections and guaranteed water quality to pure partisan politics.

But even though the complexities of politics sometimes cause a contradiction in the usual rule, the fact remains that water battles generally are fought along north-south lines. In any severe water crisis in the south, those same legislators could quickly be expected to vote their regional interest. "There's no issue that tears at the very fabric of this state like water," said Assemblyman Gray Davis (D-Los Angeles). "It's not partisan. It is purely geographic."

Davis, who was chief of staff to former Gov. Edmund G. Brown Jr., said he always thought there was some "latent envy" in the north toward the south that "expressed itself most clearly on the water issue" as Los Angeles outpaced San Francisco to become the state's major urban center. He also said northerners have a feeling that the southerners are "wasteful" and, because they reclaimed a desert with imported water, "don't respect the natural order of things."

To be sure, Northern Californians frequently seem preoccupied with thoughts of profligate Los Angelenos filling their swimming pools, washing their cars and hosing off their driveways with "our water." They ignore the fact that most of the exported water goes for agricultural uses. It is an image gleefully exploited by newspapers, especially in San Francisco.

When it appeared that Assembly Speaker Willie Brown (D-San Francisco) might support the Deukmejian plan recently, San Francisco Chronicle columnist Herb Caen wrote, ". . . I think Gov. Duke Dukereagan, an unreconstructed southerner, is serious about stealing our delta water and shipping it down there to that awful place that God intended to be parched until eternity. If the Speaker of the Assembly, Willie Wotzisname, doesn't stand up against The Dooker on this one, I say cut off his clothes."

Ex-Gov. Edmund G. (Pat) Brown Sr., a former San Franciscan now living in Los Angeles, recalled that Northern California counties never supported him again after he pushed for the state Water Project in the late 1950s. He said the Chronicle "really kicked the living hell out of me."

Never mind that San Francisco also is dependent on imported water, which it takes from the Tuolumne River.

But northerners do seem to have a reverence for water that one does not find in the south. It is more than a necessity. With the delta, plus a string of rivers and lakes, it is a treasured regional resource. In the south, said Assemblyman Terry Goggin (D-San Bernardino), "We just turn on the spigot and take it for granted water will come out."

When the first water was pumped over the Tehachapis and into Southern California via the new state Water Project on Oct. 7, 1971, Northern Californians gathered in the tiny offices of the San Francisco Ecology Center for what they called a wake. "Farewell to the sweet waters . . . we remember them well," sighed T. H. Watkins, an author and critic of the project, as the mourners popped champagne corks.

At the pumping plant 35 miles southeast of Bakersfield, meanwhile, then-Gov. Ronald Reagan was describing the project as a unifying force for California, which only goes to show how fallible governors can be. "For the first time in history, California will be united—north and south—with a water transportation system that truly distributes one of the state's most important resources," he said.

Since then, all efforts to add to the partially completed delivery system have failed, and if there was ever a vivid illustration of how difficult it will be to ever have north and south agree on anything having to do with water, it occurred with the 1982 vote on the Peripheral Canal. Los Angeles County voted for the canal by almost a 2-to-1 margin; in San Francisco, the vote was 20 to 1 against it.

William Endicott is The Times' Sacramento Bureau chief.

III. RESOLVED: THAT THE FEDERAL GOVERNMENT SHOULD ESTABLISH A COMPREHENSIVE NATIONAL POLICY TO PROTECT THE QUALTIY OF WATER IN THE UNITED STATES

State and Federal Roles in National Water Cleanup

By Carol A. Jolly

The focal point of much debate in Washington, concerning not only the Clean Water Act but virtually all domestic legislation, is: What is the appropriate role of the federal vs. state governments? This, of course, is the central issue in President Reagan's New Federalism proposal, in which he urged massive changes in responsibilities for programs ranging from food stamps to municipal wastewater facility grants. Federalism was one of the major underlying premises of the Administration's proposed 1983 Budget, which justified wholesale reductions in the fiscal and personnel resources of many federal agencies on the grounds that states would be playing a far greater role in program implementation and enforcement.

While there is widespread disagreement about just what federalism means, there is serious concern at the state level about the states' ability to take on additional environmental protection functions in light of austere state budgets and reduced federal support. State administrators believe they are already spread too thin in their efforts to manage major programs—largely based on federal legislation—for clean air, clean water, drinking water and other environmental concerns.

Anyone familiar with the history of water pollution control recognizes that a shift to increase state responsibility represents a reversal of a 25-year trend toward increased federal involvement in this field. During the first half of the century, federal involvement was primarily oriented toward assuring the smooth flow of navigation, and its vague antipollution powers were rarely enforced. In 1948, with the passage of the Water Pollution Control Act, Congress first legitimized a federal role in this field "on the basis of its power to tax and spend for the general welfare."[1]

In this law—as in each subsequent set of amendments—Congress carefully limited its own powers and emphasized state authority, declaring that it was "the policy of Congress to recognize, preserve and protect the primary responsibilities and rights of the states in controlling water pollution."[2]

In a 1981 analysis of governmental roles prepared by the Advisory Commission on Intergovernmental Relations, the ensuing development of the federal environmental role was summed up in a hypothetical series of news headlines which read:

- Washington Offers Cleanup Money to Mayors, Governors
- Feds Tell States—You Clean Up or We Will
- States Take Cue—Begin Cleanup Effort
- Public Says "No More Pollution" . . . Congress Responds—Legislates Nonexistent Technology
- Courts Give "OK" to Environment[3]

I might add to this a 1982 headline which could read:

- Public Commitment to Environment Remains Clear—Source of Funding Cloudy.

The 1972 Amendments reemphasized the primary rights of states "to prevent, reduce and eliminate pollution, to plan the development and use of land and water resources and to consult with the Administrator [of EPA] in the exercise of his authority under this Act." They went on to declare Congressional policy that the states implement the permit and construction grants programs and expressed the intent of Congress "to provide . . . financial aid to state and interstate agencies and municipalities in connection with the prevention, reduction, and elimination of pollution."[4]

The states have consistently endorsed the complementary relationship this language con-

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notes. States would manage the act's programs through delegation while EPA would establish minimum ground rules and fill in where states did not assume responsibility. Interstate agencies would address regional needs that could not be adequately met by the federal government or individual states. Unfortunately, to date this partnership has not operated as the legislative language projected.

"Some states are concerned about having to cut back on NPDES program activities,"

The National Pollutant Discharge Elimination System (NPDES) permit program provides a case in point. Many states' permit programs, which preceded the act, were essentially equivalent in results. The major effect of the act as implemented was to increase administrative requirements, program complexity and resource needs. This diversion from environmental priorities often yielded no water quality improvements but was believed necessary to assure national uniformity of substance and procedure. The philosophy was to regulate to the "lowest possible denominator." The result, in many cases, was to replace state programs with an unsatisfactory substitute.

EPA's further tendency to remain involved in program operations, regardless of NPDES delegation, has led to needless and counter-productive duplication, resource expenditures, program delay and strained federal-state relations. Rather than auditing for program results, the agency has focused far too much on case-by-case review, diverting state resources to justifying numerous individual decisions.

Because of Congressional, EPA and court actions, NPDES program requirements have continually increased over the past decade. Through this period, virtually no requirements have been dropped or simplified. All too often it has been forgotten that once a program element is in place, the effort must be maintained.

In this situation—and lacking additional resources to correspond with increased responsibilities—some states are concerned about having to cut back on NPDES program activities. In some cases, enforcement and compliance monitoring might have to be reduced, since they have been judged more "discretionary" than permit issuance.

States have also been exploring alternative financial arrangements. Some have permit or "user" fees; others are considering them. As part of its rationale for reducing state program support, the Administration contends that such fees can be used to offset these cuts. But only a few states have a fee system in place that provides anything approaching that level of support. Institution of fee systems by other states will probably take several years, because in most instances legislative approval will be required. While the concept that "the user pays" appears reasonable, it should be noted that small dischargers—which can least afford to pay large fees—often take a disproportionate amount of state officials' time. Establishing an equitable system will undoubtedly pose many problems of this type.

"State responsibilities are likely to increase . . . as toxic pollutant controls are established under new . . . limitations.

In its budget justification and in its policy documents, EPA speaks repeatedly of its intention to have states assume more programs. For example, the Administrator accepted the recommendations of an Agency Ground Water Policy Group, which advised her that, "States should have the lead role in ground-water protection [and] EPA's role should be drawn to facilitate state efforts to protect ground-water quality."[3] Similarly, the Assistant Administrator for Water's Operating Guidance for fiscal 1983 asserts that, "a central feature of EPA's management approach is to transfer authority and program responsibilities to the states."

"Encouraging state implementation," it goes on to say, "is a central element in EPA's philosophy of dealing with water quality problems closer to the level where they exist, thereby enhancing not only the knowledge of the problem but also the concern for improvements."[6]

However, at the same time, the Administration proposed to reduce its State Management Grants—the funds that are used by states to cover the personnel and costs of virtually all the Clean Water Act's programs (except construction grants)—from their 1982 level of more than $51 million to $40 million; a 20 percent cut. Fortunately, Congress did appropriate $54 million for 1983 State Management Grants. But, the reduction is likely to be reproposed fiscal 1984 budget.

States realize that more can sometimes be accomplished with less. Costs of added activities can be offset by streamlining regulations, by focusing on water quality improvement rather than on procedural requirements, and by minimizing the readjustments needed when rules, policies and guidance are continually established, revised and revoked. But even maintaining the status quo may not be sufficient. State responsibilities are likely to increase markedly over the next few years as toxic pollutant controls are established under new EPA effluent limitations.

In the states' view, federal funding for management of the Clean Water Act's programs—NPDES, compliance monitoring, and emergency response, to name just a few—cannot be viewed independently of the federal interest in meeting the goals of the act. The continuation of state agreements to voluntarily administer these programs depends on reasonable federal requirements and adequate federal funding.

> *"EPA has demonstrated distrust in the states' ability or desire to protect their waters . . . ."*

Because water quality standards set the fundamental requirements of the national water pollution program, the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA) has been particularly concerned about the respective roles of the states and EPA in the standard-setting process.

Section 303 of the Clean Water Act clearly delineates these roles. The states are to take the initiative in standards review and development. EPA is to take an active role in providing states with detailed information and technical assistance and is to promptly review and act on the standards revised or adopted. As expressed in the law, the federal and state governments are to work in a partnership.

In practice, a much different relationship has developed, one which has resulted in negative attitudes between the partners. EPA has demonstrated distrust in the states' ability or desire to protect their waters; in fact, the agency appeared to believe that states must be forced to develop protective standards. As Eric Eidsness, the Assistant Administrator for Water, put it, EPA in the past sometimes exhibited an attitude, "that everybody is presumably guilty until proven innocent and that the only organization that can define and solve environmental problems is EPA."[7]

In its recently proposed Water Quality Standards regulations, the agency has modified this approach and has adopted many of ASIWPCA's recommendations. These recommendations included adherence to several principles, among them:

- the primary role of the states in the establishment and revision of standards.
- EPA's crucial role as reviewer of standards to assure interstate compatibility and consistency with the act's requirements.
- the flexibility to tailor numerical water quality criteria to specific sites.
- reaffirmation of an antidegradation policy to maintain existing uses.

Recognizing the impracticality of revising statewide standards every three years, the draft regulations also propose that states select priority water quality limited segments and review their standards in-depth based on adequate data and information. The agency suggests that such information might come from 208 Water Quality Management Plans, 305(b) reports, local governments, industry or environmental groups; it urges states to use existing information effectively and to mobilize the resources of the state and community-at-large.[8]

ASIWPCA believes EPA too has a vital role to play in providing technical information to be used in the state review and adoption process. We would like to see the agency strengthen its research program to provide the foundation for establishment of criteria and standards. In particular, we hope there will be a greater emphasis on the effects of toxic pollutants and the long-term effects of pollutant exposure.

The debate over federalism will undoubtedly continue in the months and years ahead. There will be those who believe that progress in environmental protection can be assured only if the federal government manages the major programs and others equally are convinced that increased state responsibility is the key to further improvement. As Alexander Hamilton put it in the earliest federalist debate, preceding the establishment of our Constitution: "If mankind were to resolve to agree in no institution of government until every part of it had been adjusted to the most exact standard of perfection, society would soon become a general scene of anarchy and the world a desert. Where is the standard of perfection to be found?'"[9]

Certainly perfection has not yet been attained in our national efforts to improve and maintain water quality. But equally certain, progress has been made over the last decade. Pollution from both industrial and municipal sources has been reduced. In the states' view, actual implementation of the Clean Water Act's expressed policy of state primacy is the best means of promoting future accomplishments. If such an approach is to succeed, states must have the flexibility to administer their programs in the most streamlined, cost-effective manner possible and the authority to become the principal managers with full responsibility for delegated programs. In turn, the states will accept accountability, both to EPA and to their citizens.

Notes

1. Advisory Commission on Intergovernmental Relations, *Protecting the Environment: Politics, Pollution and Federal Policy, The Federal Role in the Federal System* (Washington, D.C., 1981), p. 6.
2. The Water Pollution Control Act of 1948, P.L. 80-845 (1948).
3. Advisory Commission, *Protecting the Environment*, p. 45.
4. The Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500 (1972).
5. U.S. Environmental Protection Agency, Memorandum from Ground-Water Policy Group to the Administrator, "Proposed Action to Improve EPA Ground-Water Protection," (Undated), p. 3.
6. U.S. Environmental Protection Agency, Office of Water Operating Guidance and Accountability System, Fiscal Year 1983 (June 1982), p. 16.
7. "Water for Living: An Interview with Frederic A. Eidsness Jr.," *EPA Journal* (March/April 1982), p. 9.
8. U.S. Environmental Protection Agency, Office of Water, "Draft Proposed Water Quality Standards Regulation," *Federal Register* October 29, 1982, p. 49234-252.
9. Alexander Hamilton, *The Federalist #45* (New York: Monarch Press, 1965).

Louis Harris Testimony
Subcommittee on Environmental Pollution
of the Senate Committee on Environment & Public Works
Washington, D.C.
December 15, 1982

It is a privilege to be here today to report to you on a study of public attitudes toward water pollution control and conservation of water resources our firm conducted for the Natural Resources Council of America. The time spent on the conceptualization, questionnaire development, field work, computerization, and analysis of the study began in June and ended in late November. The survey was basically conducted among a cross-secion of 1,253 adults nationwide. This survey was paid for by the Natural Resources Council of America, the Fishing Tackle Manufacturers Association, and the Rockefeller Brothers Fund. In the end, or course, the substance and methodology employed are the full responsibility of the Harris Firm.

One of the most common claims one hears is that while it is desirable to clean up the environment, the Public gives such efforts at best a secondary priority. In times of unemployment, the plea is that an environmental clean-up must wait until there are enough jobs, or the clean-up ought to be delayed or eased to preserve jobs. In times of energy shortages the efforts to clean up the environment are asked to wait once again until enough abundant energy is available.

Well, in this study, we have some definitive light to shed on such claims. Curbing water pollution is named by a substantial 74% of the adult population as "very important' in making the quality of life "better". ⟶

Reproduced from U.S. Congress. Senate. Committee on Environment and Public Works. Subcommittee on Environmental Pollution. American attitudes toward clean water. Hearing, 97th Congress, 2nd session. Dec. 15, 1982. Washington, G.P.O., 1982. P. 10-20.

Louis Harris, President of Louis Harris Associates, analyst in public opinion. Mr. Harris has been in the field of public opinion since 1947 and established Louis Harris Associates in 1956.

THIS IS TWO POINTS ABOVE A COMPARABLE 72% WHO SAID THE SAME ABOUT CURBING AIR POLLUTION. WHILE A BIT LOWER THAN THE 83% WHO GIVE HIGH IMPORTANCE TO CURBING INFLATION AND THE 79% WHO SAY THE SAME ABOUT BRINGING INTEREST RATES DOWN, CURBING WATER POLLUTION IS VIEWED AS EQUAL IN IMPORTANCE TO ECONOMIC GROWTH, ALSO CITED BY 74% AS VERY IMPORTANT, AND OUTSCORES THE 65% WHO FELT THAT WAY ABOUT PRODUCING MORE ENERGY, AND THE 68% WHO SAID THE SAME ABOUT MAKING PRODUCTS AND SERVICES SAFER.

THE INESCAPABLE POINT IS THAT CURBING BOTH AIR AND WATER POLLUTION ARE GIVEN A HIGH PRIORITY OF IMPORTANCE IN THEIR OWN RIGHT BY THE AMERICAN PEOPLE. THE BASIC TRUTH, HOWEVER, IS THAT BY A SIZABLE MARGIN, THE AMERICAN PEOPLE DO NOT FEEL THEY MUST OPT FOR ECONOMIC GROWTH, ON THE ONE HAND, OR AN ENVIRONMENTAL CLEAN-UP, ON THE OTHER. OR, OF FINDING JOBS TO EASE UNEMPLOYMENT, ON THE ONE HAND, AND AN ENVIRONMENTAL CLEAN-UP ON THE OTHER. BACK IN 1975, WE FOUND THAT BY 64-22%, A SOLID MAJORITY OF THE PUBLIC THEN REJECTED THE NOTION THAT IT WAS "NECESSARY TO SLOW DOWN THE RATE AT WHICH WE CLEAN UP WATER POLLUTION IN ORDER TO GET THE ECONOMY MOVING AGAIN AND TO EASE UNEMPLOYMENT." NOW, SOME 7 YEARS LATER, IN 1982, SENTIMENT HAS GROWN EVEN MORE OVERWHELMING: BY 89-6%, ALMOST ALL AMERICANS ARE CONVINCED THAT SUCH A TRADE OFF IS NOT NECESSARY, BECAUSE THEY ARE FIRMLY CONVINCED THAT WE CAN "GET THE ECONOMY GOING AGAIN AND ALSO CLEAN UP WATER POLLUTION." ⟶

NOT ONLY ARE THE AMERICAN PEOPLE IN FAVOR OF GIVING A HIGH PRIORITY TO AN ONGOING AND TOUGH PROGRAM TO CLEAN UP THE ENVIRONMENT, BUT THEY HAVE A WHOLE ROSTER OF SPECIFIC ENVIRONMENTAL PROBLEMS THEY WANT TO SEE ADDRESSED:

— BY 95-4%, ALMOST EVERYONE FEELS THAT DISPOSAL OF HAZARDOUS WASTES IS A SERIOUS PROBLEM IN AMERICA.

— BY 93-6%, AN ALMOST IDENTICAL MAJORITY FEELS THAT THE POLLUTION OF LAKES AND RIVERS BY TOXIC SUBSTANCES FROM FACTORIES IS A SERIOUS NATIONAL PROBLEM.

— BY 88-10%, ANOTHER SIZABLE MAJORITY VIEWS POLLUTION OF LAKES AND RIVERS BY SEWAGE AS A SERIOUS PROBLEM IN THE COUNTRY.

— BY 84-14%, A BIG MAJORITY FEEL THAT CONTAMINATED DRINKING WATER IS A SERIOUS NATIONAL PROBLEM.

— BY 88-11%, A DECISIVE MAJORITY BELIEVES THAT AIR POLLUTION BY INDUSTRY IS A GENERALLY SERIOUS PROBLEM IN THIS COUNTRY.

— BY 73-24%, A CLEAR MAJORITY FEELS THAT WATER SHORTAGES ARE A SERIOUS PROBLEM IN AMERICA.

— BY 80-18%, A SUBSTANTIAL MAJORITY IS CONVINCED THAT AIR POLLUTION BY TRUCKS AND AUTOMOBILES IS A SERIOUS NATIONAL PROBLEM.

— BY 70-25%, A MAJORITY FEEL THAT AIR POLLUTION BY COAL-BURNING ELECTRIC PLANTS IS A SERIOUS PROBLEM IN THE NATION.

— FINALLY, BY 61-28%, A SOLID MAJORITY OF AMERICANS FEEL THAT DAMAGE TO THE LANDSCAPE BY COAL STRIP MINING CONSTITUTES A SERIOUS NATIONAL PROBLEM.

OBVIOUSLY, ALL NINE OF THESE SPECIFIC ISSUES TESTED IN THIS SURVEY ARE VIEWED AS BEING SERIOUS IN THE COUNTRY TODAY. FOUR OF THE NINE, HOWEVER, RECEIVE SPECIAL AND URGENT SINGLING OUT BY THE AMERICAN PEOPLE: DISPOSAL OF HAZARDOUS WASTES IS SEEN AS "VERY SERIOUS" BY 74% OF THE ENTIRE PUBLIC NATIONWIDE; 65% SAY THE SAME ABOUT POLLUTION OF LAKES AND RIVERS BY TOXIC SUBSTANCES; 62% SAY THAT POLLUTION OF LAKES AND RIVERS BY SEWAGE IS "VERY SERIOUS"; AND 56% FEEL THE SAME ABOUT CONTAMINATED DRINKING WATER. PUT IT THIS WAY, BIG MAJORITIES OF THE AMERICAN PEOPLE ARE CONVINCED THAT DISPOSAL OF HAZARDOUS WASTES CONSTITUTES A VERY SERIOUS HAZARD ANYWHERE IN THE U.S., AS IS THE CASE WITH TOXIC WASTE POLLUTANTS, SEWAGE POLLUTION, OR WATER CONTAMINATION. THIS DOES NOT MEAN THAT MOST PEOPLE FEEL THAT THEIR OWN HOME AREA IS NECESSARILY FACED WITH CRISES SUCH AS THESE. INDEED, 46% FEEL THAT POLLUTION OF THEIR OWN LAKES AND RIVERS IS A SERIOUS PROBLEM, 44% THAT POLLUTION BY TOXIC WASTES IS A SERIOUS PROBLEM WHERE THEY LIVE, 33% ARE WORRIED ABOUT THEIR OWN DRINKING WATER BEING POLLUTED, AND 28% BELIEVE THEY ARE BESET WITH WATER SHORTAGES IN THEIR HOME AREA.

NOW, THE FACT THAT MINORITIES, NOT MAJORITIES, FEEL THESE PROBLEMS ARE SERIOUS IN THEIR AREA SHOULD NOT BE TAKEN TO MEAN THAT THE PROBLEMS ARE THEREFORE NOT SERIOUS FOR THE NATION. OBVIOUSLY, WHEN PROBLEMS AS SERIOUS AS THESE ARE BELIEVED TO EXIST IN THEIR HOME AREAS, THEN IT IS A MATTER REQUIRING HIGHLY URGENT ACTION. THE REAL WORRY PEOPLE HAVE IS A SENSE OF SHOCK THAT SUCH POLLUTION CAN EXIST ANYWHERE IN THE U.S. AND THE OVERHANGING WORRY THAT THEIR AREA COULD BE AFFLICTED BY THEM NEXT. INDEED, WHEN ASKED WHAT HAS HAPPENED TO THEIR OWN STREAMS, LAKES AND RIVERS OVER THE PAST 10 YEARS, 46% NATIONWIDE REPORT

WHERE THEY LIVE THEY ARE MORE POLLUTED NOW, ONLY 17% SAY LESS, AND 30% THE SAME. AND, LOOKING FORWARD TO THE NEXT 10 YEARS, 44% FEEL THEIR OWN STREAMS, LAKES, AND RIVERS WILL BE MORE POLLUTED, ONLY 17% FEEL THEY WILL BE LESS POLLUTED, WHILE 34% ANTICIPATE NO REAL CHANGE. SUCH RESULTS UNDERSCORE THE CONCERN THE AMERICAN PEOPLE HAVE THAT THEIR BASIC WATER RESOURCES ARE THREATENED BY POLLUTION AND CONSTANT AND TOUGH MEASURES MUST BE TAKEN TO KEEP THEM CLEAN OR TO CLEAN THEM UP.

SIGNIFICANT SHIFTS HAVE TAKEN PLACE JUST THIS YEAR IN BASIC ATTITUDES ABOUT EXTENSION OF THE CLEAN WATER ACT. LAST YEAR, ONLY A VERY SMALL 6% OF THE PUBLIC NATIONWIDE FELT THAT FEDERAL WATER POLLUTION STANDARDS WERE OVERLY PROTECTIVE. NOW, AN EVEN SMALLER 4% FEEL THAT WAY. A YEAR AGO, 43% FELT THAT FEDERAL WATER POLLUTION STANDARDS WERE "JUST ABOUT RIGHT", BUT THE NUMBER WHO FEEL THAT WAY NOW HAS DROPPED TO 34%. THE BIG MOVEMENT HAS BEEN ON THE DIMENSION "NOT PROTECTIVE ENOUGH", WHICH HAS JUMPED FROM 48 TO 59%, JUST IN ONE YEAR. I BELIEVE THE CLEAR IMPLICATION FROM THIS SHIFT IS NOT SIMPLY THAT THE NUMBER WHO REJECT THE CLAIM THAT THE FEDERAL LAW IS OVERLY PROTECTIVE HAS GONE FROM 91-6% TO 93-4%, BUT THAT THERE IS GROWING AND DEEP CONCERN THAT WHILE THE STANDARDS MAY BE VERY GOOD, INDEED, THE ENFORCEMENT OF THOSE STANDARDS HAS DETERIORATED, AS CONTROL OF THE FEDERAL ESTABLISHMENT HAS FALLEN INTO HANDS LESS THAN FULLY IN ACCORD WITH THE LETTER AND SPIRIT OF THE CLEAN WATER ACT OF 1972.

WHEN WE ASK DIRECTLY ABOUT THE CLEAN WATER ACT, A 94-3% NEARLY UNANIMOUS MAJORITY WANTS IT KEPT AT LEAST AS TOUGH AND INDEED, FULLY 60% WANT TO MAKE IT "STRICTER."

WANT TO MAKE IT "STRICTER." LAST YEAR, A COMPARABLE 93-4% MAJORITY SHARED THE SAME VIEW, BUT THE NUMBER WHO WANTED THE LAW MORE STRICT WAS A LOWER 52%. THUS, THE SENTIMENT FOR MAKING CLEAN WATER TOUGHER RATHER THAN EASING IT HAS RISEN FROM 52 TO 60% IN A YEAR. NOR ARE PEOPLE IN A TEMPORIZING MOOD ON ENVIRONMENTAL MATTERS. EVEN THOUGH NOT MANY EXPERTS THINK THAT ALL THE NATION'S WATERS WILL BE MADE "FISHABLE" AND "SWIMMABLE" BY 1983, AS SET FORTH IN THE ORIGINAL CLEAN WATER ACT, BY 78-17%, A BIG MAJORITY ARE CONVINCED THAT THE JOB CAN BE DONE. THE PUBLIC HAS BOTH THE FAITH THAT THE TASK CAN BE ACCOMPLISHED AND IS DEEPLY COMMITTED TO GETTING THE JOB DONE.

THUS, MAKE NO MISTAKE ABOUT IT, ANY EFFORT TO WEAKEN OR TO EASE THE CLEAN WATER ACT WILL BE VIEWED BY THE AMERICAN PEOPLE AS A SERIOUS AND INEXCUSABLE VIOLATION OF A CLEARLY EXPRESSED AND DEEPLY FELT PUBLIC MANDATE.

NOW, LET'S GET DOWN TO SOME OF THE RAZOR'S EDGE ISSUES THAT ARE THE HEART OF THE BATTLE OVER CLEAN WATER TODAY. ONE OF THE 1977 AMENDMENTS TO THE CLEAN WATER ACT, AS YOU KNOW, SPECIFIES THAT FACTORIES MUST INSTALL THE BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY (BAT) BY 1984. SOME INDUSTRIES WOULD LIKE TO CHANGE THE ACT SO THAT THE GOVERNMENT COULD GRANT WAIVERS OR VARIANCES FROM THE BAT REQUIREMENT UNDER CERTAIN CIRCUMSTANCES. WE ASKED A QUESTION ABOUT THIS MATTER IN A WAY THAT BENT FAR OVER BACKWARDS TO GET THE FULL WEIGHT OF THE OPPOSITION TO BAT INTO THE QUERY. WE ASKED: "THE CLEAN WATER ACT NOW REQUIRES FACTORIES TO INSTALL THE LATEST, MOST EFFECTIVE SYSTEMS AVAILABLE TO CLEAN UP THEIR TOXIC POLLUTANTS. ————————→

GIVEN THE HIGH COST OF MEETING THIS REQUIREMENT, WHICH ONE OF THE FOLLOWING POLICIES DO YOU THINK THE GOVERNMENT SHOULD FOLLOW — REQUIRE ALL FACTORIES TO INSTALL THE BEST ANTI-POLLUTION SYSTEMS THEY SAY THEY CAN AFFORD, OR REQUIRE ALL FACTORIES TO INSTALL THE BEST ANTI-POLLUTION SYSTEM AVAILABLE, EXCEPT THOSE FACTORIES WHICH WOULD BE FORCED TO SHUT DOWN AS A RESULT, OR REQUIRE ALL FACTORIES TO INSTALL THE BEST ANTI-POLLUTION SYSTEMS AVAILABLE", THE LAST OBVIOUSLY WITHOUT ANY EXCEPTIONS OR EXEMPTIONS BASED ON COST. WELL, NO MORE THAN 21% OPTED FOR INSTALLING BAT ON THE BASIS OF WHAT THEY CAN AFFORD, AND 23% MORE OPTED FOR BAT, EXCEPT WHEN IT WOULD MAKE THE PLANT CLOSE DOWN. A SOLID 53% MAJORITY SAID IT SHOULD BE MANDATORY THAT BAT BE INSTALLED, REGARDLESS OF COST OR CONSEQUENCES.

WE ASKED MUCH THE SAME TYPE OF QUESTION, WHEN WE QUERIED THE CROSS-SECTION: "DO YOU THINK FACTORIES SHOULD BE REQUIRED TO INSTALL THE BEST ANTI-POLLUTION SYSTEMS AVAILABLE, EVEN IF THIS MEANT THAT FEWER JOBS WOULD BE AVAILABLE OR NOT?" BY 65-27% NATIONWIDE, A BIG MAJORITY SAID PUT IN BAT, EVEN IF THAT MEANS FEWER JOBS. ALL GROUPS FAVOR BAT BY MARGINS OF 2 TO 1 OR BETTER. IN THE WEST, THEY SUPPORT IT BY 75-18%, AMONG UNION MEMBERS A 65-28% MAJORITY FAVOR BAT, AND SKILLED LABOR OPTS FOR IT BY 73-21%.

WE THEN ASKED ANOTHER TRADE-OFF, OFFERING PEOPLE A CHOICE BETWEEN WAIVING BAT FOR TOXIC POLLUTANTS OR CAUSING THE COMPANY INVOLVED TO LOSE MONEY, SHUT DOWN THE FACTORY, AND LAY OFF WORKERS. BY AN OVERWHELMING 86-12%, PEOPLE SAID THAT THE WAIVER OR VARIANCE SHOULD NOT BE GRANTED.

IN THIS SURVEY, WE PROBED IN CONSIDERABLE DEPTH ON THE ISSUE OF COST-BENEFIT ANALYSIS, ANOTHER OF THE KEY AND PIVOTAL ISSUES AT STAKE IN THE CLEAN WATER DEBATE. WE ASKED: "SOME PEOPLE FEEL THAT THE GOVERNMENT SHOULD NOT ORDER INDUSTRIES TO CLEAN UP THEIR WATER POLLUTION UNLESS IT CAN BE SHOWN THAT THE BENEFITS OF THE CLEANUP JUSTIFY THE COSTS INVOLVED. OTHERS DISAGREE AND SAY THE VALUE OF ELIMINATING UNSAFE POLLUTANTS IN WATER CAN'T BE MEASURED IN DOLLARS. WOULD YOU FAVOR CHANGING THE CLEAN WATER ACT SO THAT THE GOVERNMENT COULDN'T ORDER AN INDUSTRY TO CLEAN UP ITS WATER POLLUTION IF THE COSTS DIDN'T JUSTIFY IT, OR WOULD YOU OPPOSE SUCH A CHANGE IN THE CLEAN WATER ACT?" BY A STRIKING 74-23%, A SOLID MAJORITY SAY THEY WOULD OPPOSE CHANGES EVEN IF THE COST DIDN'T JUSTIFY IT. OBVIOUSLY, PEOPLE MEAN BUSINESS ON THE SUBJECT OF CLEANING UP WATER POLLUTION.

OR TAKE THE CASE OF SAFE DRINKING WATER. BY 92-7%, A BIG MAJORITY OF THE PUBLIC REPORTS THAT DRINKING WATER THAT COMES OUT OF THEIR TAP OR FAUCET IN THEIR HOME IS EITHER "VERY" OR "PRETTY" SAFE. DESPITE THIS CONFIDENCE, NONETHELESS, BY 65-33% A SOLID 2 TO 1 MAJORITY OF THE PUBLIC WANT TO FOLLOW A POLICY IN THE RENEWAL OF THE SAFE DRINKING WATER ACT THAT IS ALSO UP FOR REAUTHORIZATION WHICH STATES "CONTAMINANTS IN DRINKING WATER SUPPLIES OUGHT TO BE CLEANED UP IF THERE IS ANY CHANCE THAT THEY WILL BE DANGEROUS TO HUMAN HEALTH, REGARDLESS OF THE COST." EVEN THOUGH THEY THINK THEIR DRINKING WATER SUPPLY IS SAFE, PEOPLE WANT TO TAKE ABSOLUTELY NO CHANCES WITH THEIR DRINKING WATER WHERE HUMAN HEALTH AND SAFETY ARE CONCERNED. ANY PROVISION THAT REQUIRES PROOF OF "CLEAR DANGER" WILL MEET WITH STIFF PUBLIC RESISTANCE.

Now, by 1987, it is estimated that the total cost of compliance with the current standards of the Clean Water Act will be $20.4 billion, which works out to less than $100 for every person in the country. It is fair to assume that consumers do end up paying much of the cost through higher prices in products and higher taxes. Thus, it is not uncommon to hear this kind of argument, "It's all well and good that the public wants strict anti-pollution laws and regulations, but if they aren't willing to foot the bill for these efforts, they can hardly expect to see the government keep existing laws and regulation as tough as they are now." Furthermore, it's easy for people to say that they are willing to see sacrifices made for the sake of cleaner water — but they'd feel differently if they knew it meant money coming out of their pockets."

In this survey, people were asked bluntly if they would be willing to pay $100 a year more in taxes and higher prices for clean and safe water. By a thumping 70-26%, a solid majority said they were willing to pay the extra $100. Even among the 26% who wouldn't pay the $100, only 11% are die-hards who wouldn't pay something less than $100 more to keep water clean and safe.

Another section of this study deals with the roughly 70 million acres of wetlands and their preservation. A substantial 83% of the public nationwide feels it is "very important" to "keep the wetlands free from further destruction." ⟶

A BIG 69% WANT SUCH FEDERAL STANDARDS OVER THE WETLANDS MADE MORE STRICT AND 22% MORE WANT THEM KEPT AS THEY HAVE BEEN. ONLY 3% WANT THEM LESS STRICT. THUS, BY 91-3%, AN OVERWHELMING MAJORITY IN GENERAL DOES NOT WANT ANY EASING OF STANDARDS FOR THE PRESERVATION OF THE WETLANDS.

HOWEVER, WHEN ASKED WHOM THEY WOULD TRUST MORE TO MAINTAIN STRICT STANDARDS FOR PRESERVING THE NATION'S WETLANDS -- GOVERNMENT OFFICIALS AT THE FEDERAL OR AT THE STATE AND LOCAL LEVEL -- THE RESULT WAS A STAND-OFF: 48% PREFERRED FEDERAL AND 48% PREFERRED STATE AND LOCAL STANDARDS TO PREVAIL.

FOR MANY YEARS, IT HAS BEEN ASSUMED IN THE ENVIRONMENTAL AREA THAT ADVOCACY OF FEDERAL AUTHORITY ON STANDARDS AND ENFORCEMENT MEANT STANDING FOR TOUGH AND STRICT RULES GOVERNING POLLUTION. ADVOCACY FOR STATE AND LOCAL CONTROL, FAVORED BY MANY INDUSTRY GROUPS AND THOSE OPPOSED TO THE CLEAN AIR AND CLEAN WATER ACTS, WAS TAKEN TO MEAN MORE VARIABLE STANDARDS AND MORE DIFFUSED ENFORCEMENT. IN THIS SURVEY, THESE ASSUMPTIONS MAY WELL BE CAST IN DOUBT. FOR EXAMPLE, BY 55-41%, MEN WHO ARE LESS INCLINED TOWARD TOUGHER ENVIRONMENTAL CONTROLS, FAVOR FEDERAL RATHER THAN STATE AND LOCAL ENFORCEMENT OF WETLANDS STANDARDS. ON THE OTHER HAND, WOMEN, WHO ARE MUCH MORE PRO-ENVIRONMENTAL CONTROLS, FAVOR STATE AND LOCAL CONTROL BY 56-40%. CONSERVATIVES FAVOR FEDERAL CONTROLS, WHILE MODERATES FAVOR STATE AND LOCAL CONTROL OVER WETLANDS. PEOPLE IN THE SOUTH, WHERE ENVIRONMENTAL CONCERNS ARE NOT AS HIGH AS IN OTHER REGIONS, FAVOR FEDERAL ENFORCEMENT, WHILE PEOPLE IN THE WEST, WHERE SUPPORT FOR TOUGH ENVIRONMENTAL STANDARDS IN HIGHEST, SUPPORT STATE AND LOCAL CONTROL BY 51-43%. ⟶

I BELIEVE THE ANSWER MAY LIE IN THE PRECEIVED CHANGING ROLE OF THE FEDERAL GOVERNMENT UNDER THE REAGAN ADMINISTRATION. THOSE IN CHARGE OF RUNNING ENVIRONMENTAL PROGRAMS IN WASHINGTON TODAY ARE WIDELY VIEWED AS WANTING TO EASE STRICT ENFORCEMENT OF FEDERAL ENVIRONMENTAL CONTROLS. IT IS EVIDENT THAT THE AMERICAN PEOPLE WANT STRICT ENVIRONMENTAL CONTROLS, BUT ALSO ARE FEARFUL THAT THOSE NOW VESTED WITH RESPONSIBILITY OF SETTING AND ENFORCING STANDARDS ARE QUITE DEDICATED TO DOING JUST THE OPPOSITE. IN TURN, THIS HAS MOOTED AND CLOUDED ANY CLEAR-CUT CHOICE IN THE FEDERAL VS. STATE AND LOCAL CONTROL ISSUE. OBVIOUSLY, THE PUBLIC WOULD LIKE TO HAVE CONTINUATION OF FEDERAL CONTROLS, BUT IS WORRIED THAT THOSE NOW IN AUTHORITY WILL NOT ENFORCE EITHER THE SPIRIT OR THE LETTER OF THE LAW.

AS THE CONGRESSIONAL PROCESS DEALS WITH RENEWAL OF THE CLEAN WATER ACT, AN ALERT PUBLIC WILL BE DRAWING A JUDGMENT NOT ONLY ON HOW WELL THE BASIC PROVISIONS OF THE ACT ARE KEPT AND STRENGTHENED, BUT ALSO WHAT SAFEGUARDS ARE INCLUDED TO MAKE CERTAIN STRICT STANDARDS ARE ENFORCED.

CAN WATER POLLUTION POLICY BE EFFICIENT?

Jerome W. Milliman

Introduction

In 1972 Congress established the Federal Water Pollution Control Act in which the Environmental Protection Agency was given responsibility to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." Two national goals of "swimmable and fishable" in 1983 and "zero-discharge" in 1985 were set forth.

The 1972 law set up a national permit system for direct regulation of discharges from industrial and municipal sources, making it illegal to discharge wastes from point sources without a permit. The permit states discharge limitations for specific pollutants, establishes schedules for upgrading controls, and requires monitoring and periodic reports. As of February 1980 a total of 58,907 permits had been issued (15,395 municipal dischargers and 43,512 nonmunicipal dischargers).

Municipal dischargers were required to achieve a level of secondary treatment by 1977 and all other dischargers (mostly industrial) were required to use the "best practical control technology currently available" (BPT) by the same date. By 1983 municipal plants were to achieve BPT and industrial dischargers were to achieve "best available technology economically achievable" (BAT) in order to progress to the national goal of eliminating discharges of all pollutants. Note that the emphasis is on emissions from point sources. EPA was given no specific authority to regulate pollution from nonpoint sources.

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As of 1980, EPA reported that the industrial dischargers had a compliance rate of 80 percent. By contrast, municipal dischargers have been slow to comply despite being eligible for construction grants, with a compliance rate of 40 percent with the 1977 requirements. In February 1980, EPA estimated that 63 percent of major municipal treatment facilities were not yet in compliance with the original July 1977 deadline. By the end of 1979, EPA had obligated $24.4 billion in construction grant appropriations (75 percent of construction costs) to municipalities for sewage treatment plants. Construction had begun on 6,623 projects but only 1,552 were in operation. EPA inspections of operating municipal sewage plants reveal that less than one half perform satisfactorily because of operation and maintenance problems. Apparently, EPA is in a poor bargaining position with reluctant municipalities to require compliance because of lack of effective sanctions.

In the last decade some success in the control of water pollution has been achieved. A few areas have seen some dramatic improvements. Many industrial point sources of pollution are now under control, but municipal sources remain a serious problem. Moreover, more than half of all pollutants are coming from nonpoint sources that are currently uncontrolled. The most important nonpoint sources are urban storm runoff and runoff from agricultural activities. Also, toxic pollutants in surface and ground water are a major concern. For example, even though salmon are returning to the mouth of the Hudson River after a 75-year absence, they should not be eaten because of high PCB (polychlorinated biphenyls) contamination. Also, many states are finding synthetic organic compounds in wells of public water systems.

With the adoption of a program based almost exclusively on direct governmental controls, with almost no reliance on economic tests for efficiency, and with no reliance on private property and market-type approaches, no one should expect a favorable outcome. Congress has established a complex and cumbersome program of detailed regulation with a set of goals that fail to include economic scrutiny of benefits and costs. Most observers conclude that water pollution control programs in the United States are expensive, largely ineffective, and wasteful. This is ironic because the rationale for public intervention in the control of water pollution is to combat the inefficiency caused by unregulated use of water resources.

This paper will assess three instruments for management of water pollution: Direct regulation, effluent charges, and tradable permits and the role each can play in achieving efficient water pollution control. We will look at the failure to estimate benefits stemming from present policies and possibilities for more reliance upon market mechanisms and property rights in efficient water pollution policies. Finally, we will focus on the need to adopt policies that deal with management of nonpoint sources, groundwater protection, and the control of toxics. These areas tend to be neglected in a policy aimed largely at controlling point sources of conventional pollutants in surface waters by direct discharge regulation.

Defining Pollution

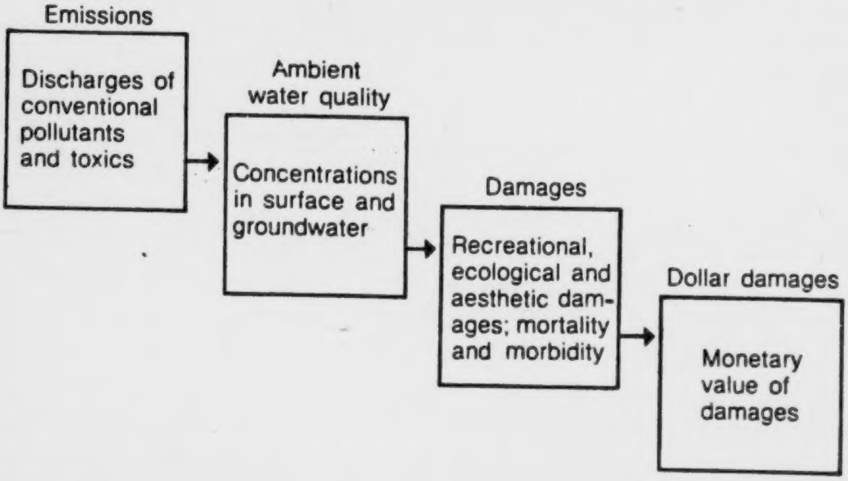
Pollution can be defined as damage to the services provided by the environment caused by the disposal of residuals from production or consumption activities. The discharge of residuals includes heat, noise, and damage to aesthetics as well as the discharge of solids, liquids, or gaseous materials. We will be concerned with the pollution caused by the actions of man although it is clear that the actions of nature also cause the emission of materials into the environment that can reduce its services. Air pollution from volcanic action is well-established. Likewise, natural oil seeps can cause damage to aquatic food chains.

The cost (or damage) of pollution is the value of environmental services foregone by the disposal of residuals. The damage to the environment is both a function of the volume of discharge in relation to the assimilative capacity of the environment and the location of the use of that environment (primarily by the location of receptor activities). In other words, if there is little stress on the assimilative capacity or if there are few activities harmed, the damage will be small.

Four Steps in Estimating Pollution Damages

Four steps are required to go from estimates of water pollution discharges to dollar estimates of damages. Each step involves information gaps and measurement error, and the level of ignorance increases with each step. As can be seen from Figure 1, pollutants like conventional biochemical oxygen demanding substances (BOD) or toxic pollutants such as asbestos, benzene, or mercury are first shown as emissions. We then progress to ambient water quality in streams, lakes, or underground waters. Changes in ambient quality produce damaging effects on humans, plants, wildlife, and property. Step three involves identifying an adverse effect and attributing it to the change in ambient quality; i.e., specifying the dose-response function. In step four the researcher attempts to put a dollar value on the damages sustained from water pollution or, conversely, on damages averted by pollution abatement.

FIGURE 1
STEPS IN ESTIMATING POLLUTION DAMAGES


Emissions
Discharges of conventional pollutants and toxics
Ambient water quality
Concentrations in surface and groundwater
Damages
Recreational, ecological and aesthetic damages; mortality and morbidity
Dollar damages
Monetary value of damages

Steps one and two involve the assembling of data on emissions and on ambient quality from both point and nonpoint sources for various surface waters and for ground water. The problems associated with water quality data are immense — the sparsity of data, nonrepresentative monitoring sites, and limited detection capability for some pollutants make for poor data quality. There is also a lack of coordination across programs. A federal task force found more than 100 water monitoring programs managed by 20 federal agencies, which spent approximately $275 million in 1978 (CEQ 1980). State and local monitoring were not studied.

Surface waters are visible and tend to be better monitored. Less visible ground waters finally are receiving attention because of contamination from toxic organic and inorganic chemicals. Because ground water is widely used for drinking water, infiltration of toxic chemical pollutants may be posing health risks. Only recently has EPA instituted a statistically designed monitoring survey for ground water.

Nonpoint sources of water pollution are ones where there is no obvious outfall or pipe for discharge. Nonpoint sources are diffuse, difficult to identify and to control. The most important nonpoint sources are runoff from agricultural operations, urban storm runoff, runoff from mining and forestry activities, and from individual septic systems. The General Accounting Office has found that more than one half of all water pollution is from nonpoint sources (GAO 1977). Yet the Clean Water legislation and economic literature devote little attention to this problem. More control of emissions from point sources may do little to improve ambient quality where nonpoint pollution is serious.

Using U.S. Geological Survey (USGS) data and EPA water quality definitions, the Council on Environmental Quality (CEQ 1980) analyzed six pollution indicators in rivers and streams. The pollution indicators were for fecal coliform bacteria, total phosphorus, dissolved oxygen, total cadmium, total lead, and total mercury. The results showed little or no change in ambient water quality from 1975 through 1979. This has been interpreted as "good news" since population and gross national product increased during the period. However, it appears that EPA criteria for swimming and preservation of aquatic life were frequently violated by the indicators.

In step three it is fair to say that the range of uncertainty about dose-response functions is large. There is considerable debate about the existence of thresholds and factors of safety. Responses vary greatly among individuals, property, and plant and animal species. Long-term and short-term exposures cannot be equated. Also, epidemiological studies are scarce.

With regard to damages caused by low ambient quality, the usual practice is to employ thresholds developed by EPA for water quality and to assume that violations of these thresholds cause damages. However, the extent or quantitative measure of the damages resulting from violations of thresholds and standards is not known. That is to say, *reliable measures of total damages stemming from water pollution by region or by watershed do not exist.* Furthermore the thresholds developed by EPA are not universally accepted. In its study of water quality conditions for surface water, CEQ used annual median concentrations for 1975 to 1979. Although annual median concentrations may be useful to pick up violation rates for thresholds, such data do not say very much, if anything, about the actual extent of damages. The thresholds themselves appear to be related, for the most part, to the preservation of aquatic life. Yet data on damages to aquatic life resulting from these threshold violations in the field do not exist.

Step four involves putting dollar values on damages sustained from water pollution or, conversely, on damages averted by pollution abatement. As one might expect from the discussion of damage estimates in step three above, *there exist no credible estimates of the overall benefits being conferred by the federal water pollution control program*. In this context, Mills (1978, p. 128) has stated: "It is incredible that an expensive national program has been undertaken with almost no analysis of the benefits it will confer on society."

It is generally believed that the major source of benefits from water pollution control will be from enhanced water-based recreation (swimming, boating, and fishing) and aesthetics. A report prepared for EPA in 1976 using 1973 dollars, but estimating benefits of water pollution control upon hypothetical conditions expected to prevail with use of best available technology and zero discharge in 1985, found that annual benefits would be $10.1 billion a year from eliminating all water pollution. More than 60 percent of all estimated benefits were from recreation. Ackerman et al. (1974) examined proposed recreational benefits from cleaning up the Delaware River and found them to be trivial in comparison with the costs. Freeman (1979) points out that there is a substantial body of research on estimating demands for outdoor recreation, but little work has been done on the role of water quality in influencing the demand for recreation. Because of insufficient evidence no one has attempted to estimate the health benefits from the elimination of possible chemical contamination in drinking water.

A complete economic analysis would require a comparison of the benefits with the estimated costs of control. No such study has been made. We cannot even find an estimate of the total costs of water pollution control to date. CEQ (1980, p. 394) estimates that annual costs for "incremental" (the increase in spending because of new regulations) federal water pollution abatement were $12.7 billion for 1979 alone. The cumulative estimate for 1979-1988 was given as $169.7 billion for federal programs and $250 billion for all federal, state, and local regulation.

As far as we can tell, these future cost estimates are largely for control of point emissions with virtually no attempt to cost out control of nonpoint emissions. There are two aspects of the omission that need to be stressed. First, costs for control of nonpoint emissions are likely to be high. Second, unless we control nonpoint emissions, the incremental benefits of increased control of point emissions may not be very large.

Already, we have seen that the control programs on point emissions through 1979 have not improved water quality as conventionally measured. Regional improvements in some areas are evident, but on a national level, the best we can conclude is that surface water quality has not deteriorated in the face of growth in population and GNP in the period 1975 to 1979; in other words, national water quality is virtually unchanged. One must be skeptical that a continuation of present programs of expenditure and control for point emissions will lead to dramatic improvements by 1983, 1985 or 1988. It now appears that the EPA's report (1976) on benefits to be forthcoming in 1985 from zero-discharge was based upon conditions not likely to be reached in 1985 or perhaps ever. More importantly, it is not at all clear what is meant by zero-discharge considering the magnitude of nonpoint problems. Given the large expenditures involved in pollution control, there is a good case for benefit estimates. Why is there so much reluctance to get on with the task?

Causes of the Pollution Problem

A key assumption in our discussion of damages from water pollution is that social welfare is to be judged by individual needs and wants. This value judgment is central to our examination of the role of private markets and government in providing the water quality demanded by society. Acceptable water quality is not now adequately provided for by private markets. It is an example of a good for which people may not be able to judge what is in their best interest because they may have little information on the effects of water pollution.

Government should provide better information about the level of water quality and about the effects of water pollution so that individuals and firms can better make their own decisions. Ignorance on the part of individuals is usually a poor rationale for collective action. In fact, lack of knowledge about levels of ambient water quality and about dose-response functions is also an obstacle to efficient public decision-making as well as individual choice. We wish we could guarantee that public institutions will make fewer mistakes and have better information than market institutions. This pervasive ignorance may be as much of a problem as the question of market failure.

If there are no markets for clean water or if markets for water resources do not function properly, the resulting prices do not convey correct signals about water quality demand and supply. In general, the water pollution problem is one of economic inefficiency stemming from market failure. There are two relevant sources of market failure, which provide the basic rationale for public policy either to strengthen or to replace markets to determine optimal water quality. However, these sources of market failure may create problems for collective decision-making as well.

The first is the lack of well-defined property rights. Water resources tend to be mobile, and the size of the unit for vesting property rights tends to be very large. This is particularly true for large bodies of water and for river basins crossing state lines. For some purposes, control of a major river system is indivisible. It was argued earlier (Milliman 1959) that state water law could go much further in treating water rights as private property so that water use could be allocated through the market mechanism. Although the reasoning developed at that time applied mainly to the use of water for irrigation, it is clear that water rights could be developed for water-borne waste disposal from point sources and for many aspects of water quality. In fact, where it has been possible to specify water rights through the law of appropriation in some western states, limited markets in water rights have developed that deal at least in part with water quality problems stemming from waste disposal.

The worst water pollution problems in the United States are found in eastern states where development of market mechanisms for water resources has been virtually nonexistent. The major limitations of the water-law approach involve sources of nonpoint pollution, e.g., urban and agricultural runoff and for instream uses where access cannot be controlled. However, as noted above, public policies for pollution control using nonmarket approaches are ineffective on nonpoint pollution problems. If we can develop government regulations for the discharge of emissions of pollutants from point sources, we can develop property-rights and market-type solutions for point sources. All aspects of water resource use do not have to remain inflicted with the common property syndrome.

The second source of market failure stems from water quality as an environmental amenity. Some aspects of water quality, once supplied, are equally available to all. Since users cannot be excluded for nonpayment, there is no obvious way that private producers operating through markets could produce and sell clean water. As a result, the market system will tend to underproduce clean water.

This public good aspect of water quality offers no incentives to consumers either. This is the "free rider" problem. Individuals receive a certain level of water quality regardless of what they contribute. The dilemma is how to get people to reveal their preferences for clean water and yet accept responsibility for sharing the costs.

It is not clear just how important the public good aspect really is. Certainly the problem of excludability is much greater in dealing with air pollution than it is with regard to many rivers, lakes, and underground waters that have fairly well-defined flows and locations. This means that ways to control access and segregate uses could be devised for many kinds of "mobile" water resources. Water quality for swimming, boating, and fishing could have some aspects of exclusion and therefore allow market-type mechanisms, to some extent, to determine preferences. Users could be asked to help bear costs and to allocate water quality resources for recreational uses, particularly if waste discharges also had to compete for emission rights. Preserving the aesthetics of a lake or river basin may be the strongest argument for the public good feature. It is possible that aesthetics will be much less of a problem once the question of how much to invest in water-based recreation is decided.

We do not want to push these ideas too far at this point because we want to go into more detail below. It is clear that there are all sorts of problems in dealing with market-like solutions for determining the "optimal" level of water quality. Can property rights be defined with sufficient precision in enough cases to create markets? Can a large number of downstream consumers negotiate effectively with upstream polluters? How should pollution rights be vested? Will the market solutions approximate competitive outcomes? It is clear, however, that once the goal of efficiency is established, the search for clean water strategies will change considerably. The important problem, at this point, is not market versus nonmarket strategies but goals: Do we want clean water at any price or do we want water pollution policies that are socially efficient and subject to careful studies of benefits and costs?

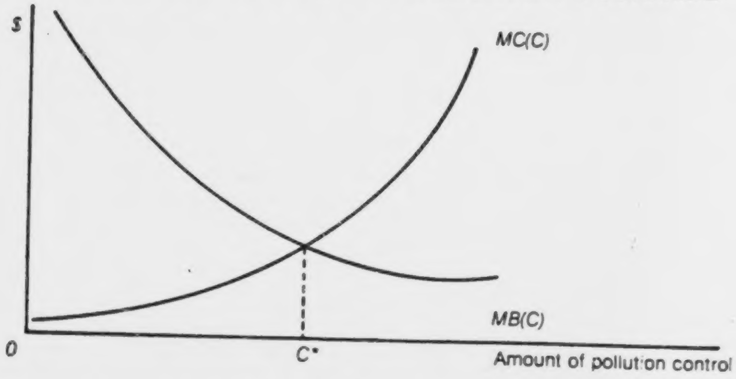
The Efficient Level of Pollution Control

To some people the notion that there is an optimal level of pollution control and therefore an optimal level of pollution is very disturbing. Indeed, the federal legislation states: "It is the national goal that the discharge of pollutants into the navigable waters be eliminated in 1985." Holders of this point of view believe that any amount of pollution is undesirable and that it should be eliminated despite enormous social costs.

It is our view that the discharge of residuals is a legitimate economic activity, which is socially undesirable only when the damages exceed the cost of control. Moreover, the label of "pollution" covers a multitude of discharge activities, some of which are far more serious than others. It is nonsense to contemplate the immediate elimination of all forms of pollution. Deadly toxic discharges are a very different matter from discharges of degradable organic wastes into waters having large amounts of dissolved oxygen. Finally, the control of pollution involves the use of scarce resources and opportunity costs. Although pollution control may prevent damages, there can be too much pollution control as well as too little. How far do we go?

Society's willingness to pay for a cleaner environment can be illustrated by a marginal benefit *(MB)* function. The *MB* function shows the marginal damages averted by additional pollution control. Figure 2 shows the relationship between the *MB* function and the marginal costs *(MC)* of pollution control for environmental quality. The socially efficient level of pollution controls is the value C^* where the marginal benefits of control equal the marginal costs of control, or $MB(C^*) = MC(C^*)$.

FIGURE 2
THE OPTIMAL LEVEL OF POLLUTION CONTROL



It can be shown that C^* is the level of control that is socially efficient. If the level of control were to the right of C^* the increase in control costs would exceed the increase in benefits of improved environmental quality. To the left of C* the level of control would be too small. It can also be shown that at C* the sum of the residual damages plus the treatment costs will be minimized. Note that this reasoning usually implies that some residual pollution remains at C*.

This logic is widely accepted by economists, but has not been adopted as a matter of public policy. If the goals of public policy for water pollution control refuse to recognize that there is an optimum level of control involving comparisons of *MB* and *MC*, then we will make little progress. It will not be useful to argue the merits of market and private property approaches to pollution control versus collective and centralized decision-making unless there is a commitment to this logic.

How one applies the logic will probably continue to be controversial. How to estimate the *MB* and *MC* curves will remain a very difficult task for which there may never be precise answers. As we saw in the discussion of the four steps to estimate pollution damages, much of the information needed to compute *MB* curves is lacking. We know too little about dose-response functions. The presence of nonpoint sources of pollution makes the prediction of concentrations and the level of control costs difficult. The randomness and dynamic nature of the real world will cause the functions to shift. Finally, the distribution of benefits and costs of pollution control policy will always be a source of public debate. Nevertheless, the existence of a theory of the optimum level of pollution control is central to policy formation and implementation.

Efficiency Without Optimality

Ideally, then, pollution control measures should be pursued up to the point where the *MB* of control equals *MC* of control. But what do we suggest when we have little information on the shape and position of the *MB* function? Rather than do nothing or futilely ban all pollution, it has been proposed that achievement of predetermined ambient standards be used as the benefit function of environmental policy. For example, where the policy-maker is unable to develop an *MB* function for recreational fishing, the environmental agency might set a minimum standard of 5 milligrams per liter of dissolved oxygen to be maintained in a stream subjected to the discharge of BOD wastes. This standard would preserve fish life. In such cases Baumol and Oates (1975) have argued for the second-best approach of efficiency without optimality. The standard would be taken *provisionally* as given and the efficiency goal would be to minimize the cost of achieving that goal. Pollution control strategies would then be judged by their relative efficiency in achieving the standard.

There is much to be said for efficiency without optimality when the information required for an optimal solution does not exist. As we shall see below, the price system and market mechanisms can be employed to achieve environmental standards in a least-cost manner. Of course, once the minimum cost of achieving a standard is known, we will then be able to infer the minimum benefit the standard must have in order to justify its continuation. Acceptance of standards or environmental targets should not be used as an excuse not to implement step three and attempt to quantify damages in physical terms.

Alternative Pollution Control Strategies

We have argued that the goal of environmental policy should be to correct for market failure and improve efficiency in the allocation of environmental resources. We have suggested that the *MB* of control should be equated with the *MC* of control; short of that, the least-cost achievement of predetermined standards is the second-best goal. We have expressed concern that current environmental policy appears to have goals that are unrelated to either optimality or efficiency. In this section we shall analyze various pollution control strategies, with the primary basis for judgment their relative efficiency. The present policies for water pollution control not only have goals that pay little heed to efficiency, but also employ strategies or instruments that are not efficient. We will suggest that the market mechanism and property rights can play a greater role in policy for water pollution when efficiency in resource use is desired. The strategies, however, have limited applicability for curbing nonpoint pollution in an efficient manner, and implicitly assume that the pollution problem to be solved is one of control of point emissions.

Direct Regulation

The management strategy that is the backbone of current U.S. water policy is the use of the police power of the government to regulate either the output of residuals directly or to regulate the inputs used in production. Input regulation requires firms to adopt certain kinds of equipment or treatment processes, such as secondary treatment of municipal wastes. Output standards tell a discharger how much emission is allowed at each source. Here the firm is allowed to determine the method for reducing emissions as long as the target is reached.

The economic literature is virtually unanimous in its criticism of the regulatory approach to water pollution control. The major criticism of direct regulation is that the information requirements to attain efficiency are not likely to be met. To determine the optimal input and output standards, the regulators would need to know the *MB* and *MC* functions of each discharger. If this information were known, regulation could be used to establish C^* for each of the dischargers and to set the optimal amount of ambient quality consistent with equality of marginal damages averted and marginal costs of control. With many dischargers and many receptors, going through the four steps to determine damages and then comparing incremental damages with a myriad of control cost functions is mind-boggling.

As actually practiced, the strategy of direct regulation is a more manageable task. First, some predetermined ambient quality standards are selected so that information on *MB* functions is not required. If efficiency without optimality were the second-best goal, the regulation strategy would attempt to set discharge regulations for each discharger so as to minimize the total cost of achieving the ambient quality target. Even in this second-best case, the information requirements for efficiency are formidable. It is not realistic to assume that regulators possess the necessary cost information on treatment of residuals for each of the dischargers under their jurisdiction in order to minimize control costs.

In the absence of such cost information, the regulators adopt shortcuts that often come out of tough bargaining sessions between regulators and dischargers. At issue is the cost and availability of control methods to be used in meeting discharge permits. In most cases, the bargaining process results in detailed and comprehensive regulation when the range of control techniques is large. However, the end result is usually some form of uniform cutback or uniform percentage abatement of emissions from previous levels. Regulators are under great pressures to treat different dischargers in the same region equitably. This means that "fairness" requires uniform percentage abatement.

Uniform percentage abatement is known to be wasteful; it fails to minimize total treatment costs. Since costs of pollution control vary greatly among sources, a policy of uniform percentage treatment is bound to be more costly than a policy which would equalize treatment costs at the margin among dischargers. Kneese and Bower (1968) found in a study of the Delaware estuary that a policy of uniform effluent charges would achieve given quality objectives at about half the cost of uniform percentage emission regulation.

Mills (1978) has also shown that under direct regulation, dischargers pay nothing for their quotas. The direct discharge policy prevents a discharger from discharging more than its quota (or treating a uniform percentage). If firms were subject to effluent charges on emissions, there would be no "free" quotas. They would have to either treat or pay a charge on *all* emissions. As a result, their costs of production would be higher and output less. By contrast, firms subject to direct regulation have lower costs, resulting in overproduction.

Buchanan and Tullock (1975) have shown that even with perfect information a system of direct regulation cannot be efficient because an incentive would remain for new firms to enter the industry. Without controls on entry and output the number of firms would grow, producing an inefficient output. The agency would also have to regulate where the firms may locate in a region in order to deal with interactions on ambient quality and on damages among emitters and receptors.

Kneese and Bower (1968) have also pointed out that direct regulation, in comparison with effluent charges, offers no incentive to the discharger to do more than meet standards. Charges have the advantage of placing continuous pressure on the discharger to improve his waste treatment processes. They also argue that effluent charges yield revenues so that the administration costs come more from the consumers and the firms involved than from general taxpayers. As we shall see below, this may generate political opposition from firms and agencies unwilling to bear the costs of effluent charges, particularly municipal discharges.

There are two instances where direct regulations can be defended. First, as Baumol and Oates (1975) have argued, effluent charges and tradable permits suffer from a serious liability as a means of pollution control because the number of permits or the effluent charge may be very difficult to change on short notice. During emergency periods when water levels are excessively low, emission levels suitable for normal periods may be inefficient or even intolerable. Some meteorological conditions are not easily foreseeable. For such "crisis" conditions, a temporary program of direct regulation of discharges may be justified.

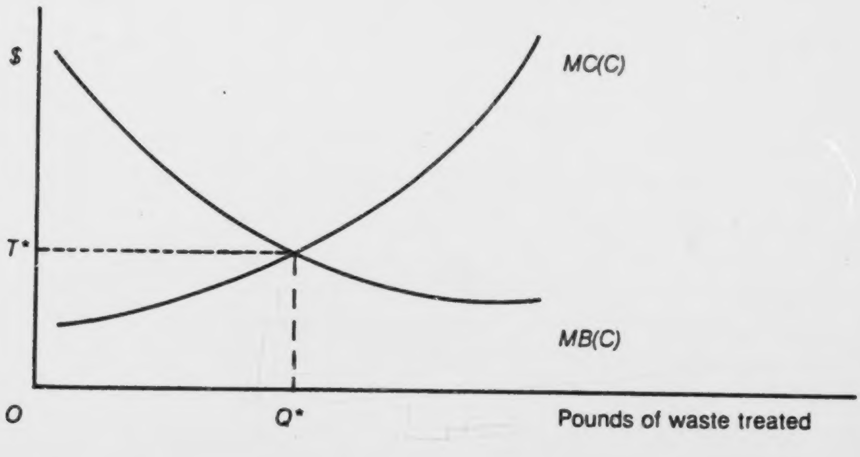
Second, Dorfman (1977) has argued that the correct effluent charge may be found only after some experimentation, and the risk of having dangerous concentrations of effluent may not be worth taking. In such cases direct regulation, despite the failure to minimize costs of treatment among dischargers, may avoid a more serious risk of dangerously high emission levels.

Effluent Charges

Most economists advocate effluent charges as the primary strategy for water pollution control. Stemming from the work of Pigou, taxes have long been advocated to correct for divergencies between marginal private costs and the marginal costs of pollution imposed upon third parties. In recent years, a strong case for effluent charges has been presented by Kneese and Bower (1968) and by Baumol and Oates (1975).

The difficulties of setting up an optimal set of effluent charges are essentially the same ones that face a regulator in establishing an optimal set of direct discharge regulations. In a world of perfect information the regulator would know the *MB* or marginal damage functions connected with each source of emissions. The regulator would also know the *MC* functions of all of the treatment options available to each discharger. The proper effluent charges on discharger A at location B would be T^* as shown in Figure 3 and the optimal amount of abatement would be Q^*. However, the regulator must

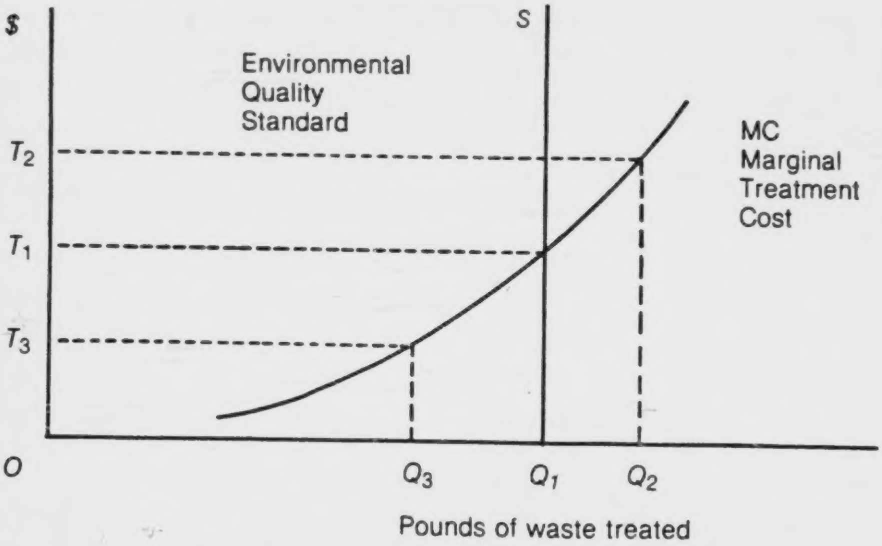
FIGURE 3
OPTIMAL EFFLUENT CHARGE



also have an accurate understanding of the effects of discharges at other locations and also the effects that effluent charges will have on other polluters. It is apparent that the degree of knowledge required to administer a system of optimal charges is completely unrealistic. As a consequence, *all* of the effluent charge schemes proposed are second-best approaches, which attempt to achieve some predetermined standards at the least cost, i.e., efficiency without optimality.

Figure 4 illustrates a "practical" scheme. The vertical S curve representing a predetermined environmental quality standard replaces the MB function from the preceding diagram. We assume that a discharge of Q_1 will meet some standard of environmental quality, e.g., dissolved oxygen of 5 milligrams per liter.

FIGURE 4
EFFLUENT CHARGES AND ENVIRONMENTAL QUALITY STANDARD



The correct effluent charge is T_1 which is equal to the marginal costs of treatment at the intersection with the environmental quality standard.

Assume, however, that the regulator does not know the position of the MC function and therefore has to guess at what level to set effluent charges in order to achieve the environmental quality standard. If the effluent charge is mistakenly set at T_2 because it is believed that treatment costs are higher than they turn out to be, the quality of waste treated will be Q_2 and the environmental standard will be exceeded. By contrast, if the effluent charge is set too low, say at T_3, because it is believed that marginal treatment costs are lower than they are, the level of treatment will be Q_3. Then environmental standards will not be achieved. It is hoped that through an iterative process, with changing effluent charges affecting the amount of treatment, we will converge at T_1 and Q_1.

It should be noted that the effluent charge approach achieves the least-cost combination for reaching the standard. As effluent charges are raised, a discharger will tend to cut back on emissions (treat waste) until the marginal cost of treatment is equal to the charge. Note, however, that all dischargers in the area are subject to the same tax. Therefore, the marginal cost of treatment will be equalized across all dischargers. This insures that total costs of treatment are minimized because any change in this pattern would involve either an increase in emissions or an increase in costs of treatment.

Effluent charges appear to be very attractive. They require relatively little knowledge about marginal costs of treatment for different kinds of firms and discharges. Also, they lead automatically to the least-cost pattern of achieving a given environmental standard. Compared with the drawbacks of direct regulation, these are major accomplishments.

There are, however, some problems with the effluent charge scheme. First, assume that the standard of environmental quality to be achieved is an important threshold. For example, assume that most fish will die if the level of DO falls below 5 milligrams per liter. If the tax is set too low, the environmental standard will not be achieved and the costs of being wrong may be very high.

Second, the system of iteration may impose substantial compliance costs upon dischargers. Often the investment costs in pollution abatement measures will be high. If the discharger perceives that the level of effluent charges is temporary, the firm will be reluctant to invest. This might lead to a destabilizing effect as opposed to a convergent process. If polluters are reluctant to invest in treatment because they think effluent charges will change greatly they may pay the charges and do little treatment. The control agency, in response, raises the charges. And instead of investing in treatment, the discharger might move from the region, even though the firm would have operated efficiently if the initial charge were close to the equilibrium rate.

Third, when firms enter or leave the region, the control agency will have to raise or lower the tax to reach the environmental standards. This may induce a new search process and create some instability. The agency is also perplexed about how much to raise or lower the effluent charge, so considerable instability can exist during periods of growth or decline in a region.

A fourth problem with the effluent charge strategy is how to set the "correct" zones or regions to which the charge will apply. In fairness, the problem of zonal definition is endemic to all strategies that depart from an individual policy for each point source of emissions. Ideally, of course, it would be desirable to have a separate schedule of effluent charges for each discharger. It is clear that the administrative burdens of such a system would be unreasonable. Therefore, the use of zones would allow common effluent charges and environmental standards to be specified within a given zone and different charges in other zones to secure the standard where costs of treatment differed. The problem of zonal definition arises where there is no natural clustering of dischargers. If dischargers in Zone A have an effluent charge of 10 cents per pound of BOD discharged and those in Zone B are charged 15 cents, it is clear that questions may arise as to where to draw the boundaries and how to treat firms located near boundaries equitably. Ackerman et al. (1974, p. 274) found this question of zonal definition to be a major problem in the case of the Delaware River Basin Commission. In order to reduce the pressures upon the commission, zonal differentials were made very small. Even so, the amount of "pushing and shoving" was considerable. However, a common environmental standard and effluent charge on point discharges all along a stream would reduce most of the efficiency gains that would come from relating discharge standards to ambient quality and to the use of the stream for different purposes in different sections. We will argue below that the pressures for uniformity of treatment across zones may be less intense under a system of tradable permits.

Finally, a system of effluent charges may run into political opposition from dischargers who rightly see that they either have to treat or pay "taxes" on all discharges. There will be no free rides, as with permits. Costs to firms will be higher than under direct controls (an advantage of the system) so it will be in the interests of dischargers to oppose effluent charges. In addition, special political pressures on the regulatory agency could come from municipalities that argue that they should be treated differently from firms because the effluent charge would put a financial burden on them. There is no analytical argument for giving cities special treatment.

In fact, subsidies to cities would create incentives for industries to join municipal systems. Perhaps the lesson to remember is that in presenting logical solutions to problems one cannot neglect political factors.

A system of effluent charges implies that the property rights in the water system have been vested in the water users. This means that if the standards to be achieved are based upon the preservation of aquatic life, such activities as boating, swimming, and fishing, as well as aesthetic appreciation and the preservation of the ecology of the water resource, have a vested right. The regulatory agency or the state acts as an agent for such uses, and it sells rights to discharge waste depending upon the assimilative capacity of the water resource and the standard chosen. The effluent charge minimizes the cost of achieving the standard, with the revenues realized as a kind of economic rent earned by society from use of the assimilative capacity of the water. Kneese and Bower (1968) suggest that the revenues can be used to cover the costs of administration of the program and to finance large-scale regional facilities (taking advantage of economies of scale) to improve water quality and lower treatment costs for all. Baumol and Oates (1975, p. 196) show that the dischargers will suffer a welfare loss, even though the community gains, from the imposition of charges to correct externalities unless they share in the tax revenues. It would seem that political opposition to effluent charges could be reduced if provisions are made to share revenues.

It has often been pointed out that the logic of effluent charges can be reversed to justify the payment of subsidies to dischargers by the users of the environmental services (the public). In this case the property rights would be vested in the dischargers. The state would then act as the agent for the public and "buy" reductions in waste discharges to improve water quality. Theoretically, it can be shown that the subsidy and the effluent charge can achieve equivalent results on the equilibrium position of individual firms in terms of the reduction of emissions and minimizing costs of control. However, as Baumol and Oates (1975) have shown, the subsidy approach encourages the entry of firms (while the effluent charge approach encourages their exit) so that the industry output is greater, and this may offset reduction in emissions by individual firms from subsidies.

Krutilla and Fisher (1975) point out that the initial vesting of property rights in the public will change the distribution of wealth. And with such a change, preferences for environmental services over other goods and services may shift. As a result, the optimal amounts of environmental quality and waste disposal may change, which could affect the optimal effluent charge or subsidy. This is contrary to the position taken in Coase (1960). The outcome of the bargaining is not independent of the initial vesting of property rights.

Tradable Permits

In contrast to the large amount of economic literature on effluent charges, there is very little on tradable permits. Some of the important references are Dales (1968), Montgomery (1972), Ackerman et al. (1974), Roberts and Spence (1976), Ackerman (1977), Tietenberg (1980), Lewis (1981), and Halm and Noll (1981). The theoretical case for tradable permits is quite strong; they appear to offer substantial advantages over effluent charges. It remains to be seen, however, how applicable this strategy is.

Recently, EPA has developed three limited versions of the tradable permits concept, which are being applied experimentally to air pollution at various places in the country. They are:

1. *Bubbles:* Plants are allowed to reduce controls on air emissions in a portion of the facility where abatement costs are high, in exchange for an increase in control in the same plant where abatement costs are lower. Multiplant bubbles have recently been suggested.
2. *Offsets:* In a given air shed a firm may increase emissions if it pays for a reduction in emissions from some other source in the same region.
3. *Banks:* A discharger that exceeds its emission standard may get credit for some fraction of the excess reduction in emissions in an "emission bank." Credits could then be sold to other firms seeking emission permits. Rules for trades are now being worked out.

Although these new options do not yet have well-established procedures governing transactions, they do show a new concern by EPA to minimize the costs of attaining standards and also an appreciation of how market-like approaches can offer incentives to dischargers. Their long-term status is unclear. It also remains to be seen whether the permit transactions move closer to trades of property rights. We do not know if EPA is taking similar approaches to water pollution.

Under the tradable permit system, the regulatory agency would determine the maximum total discharge of a pollutant to be emitted in a given region. Permits to discharge some fraction of this total would be printed and auctioned off or distributed in some fashion among dischargers. From then on, the allocation of emissions among dischargers would be determined by the market. Firms could buy permits in the original auction or purchase them from other firms or individuals. The government agency would have to monitor emissions to see that they were conforming with the discharge permits. Nothing would prevent individuals or groups who value clean water from buying permits and holding them idle.

The policy issues to be decided in the regulatory agency would be: (1) the environmental standard for ambient water quality; (2) the relation of total emissions to ambient quality; (3) the size of the region and whether to allow exchange of permits across zones; (4) the length of life of the permit; (5) how to issue the permits and then maintain a market for them; and (6) whether to change the ambient quality standards and number of permits as conditions warrant. Each of these policy issues involve a certain amount of "arbitrariness" and soul-searching. There are no obvious answers in a world of imperfect information.

It can be noted at the outset that the market here is not a true market in that the number of permits would be fixed in relation to some predetermined environmental target. Thus, the market only works on one side, that of rationing a fixed supply among a group of demanders. There is no feedback from the users about water quality achieved and their willingness to pay on the supply of rights, which is predetermined. A rise in the price of tradable permits signals only that permits are more in demand, but presumably it does not affect the amount supplied. This is clearly another case of efficiency without optimality. Each firm would buy or sell permits until the price of permits equaled the marginal costs of control. Since all firms would face the same permit price, marginal costs would be equated across the region and the total costs of abatement would be minimized. In a multiperiod situation the long-run marginal costs of control would be revealed by the equilibrium price of tradable permits.

The tradable permit scheme does not require knowledge of the marginal costs of treatment on the part of the agency nor does it require an iterative search for the correct effluent charge. Instead, the market makes the necessary calculations in the course of reaching an equilibrium price for permits. Thus, there is less chance of making an error on an important threshold. With effluent charges, the search for the correct charge may result in too little treatment and thus prove to be a costly mistake. Also, in the case of economic growth in the region, the regulatory agency does not have to guess how high to raise the effluent charge. New firms would have to buy up rights from existing firms, thus allocating pollution rights economically while still preserving environmental quality. Market adjustments in the price of pollution permits would be more flexible than administration of effluent charges in accommodating either growth or decline in a region. Currently all dischargers are required to have (nonmarketable) permits, so it may be easier to move to a system of tradable permits than establish a system of effluent charges.

Despite the advantages of a system of tradable permits, a number of difficult questions must be answered before we can be certain that efficiency can be achieved. Thus far we have assumed that there will be a large number of buyers and sellers of permits and that there will be a competitive long-run equilibrium price that will minimize abatement costs and yet distribute emissions among sources at various locations to meet certain ambient water quality standards. This is a tall order, which may be difficult to achieve in given watersheds. What are some of the implementation problems for a scheme of tradable permits? Will its application be restricted?

The basic questions go back to whether a competitive market can be constructed and how complex the technical relationships are between emissions (from point sources) and ambient quality. With regard to technical relationships, what pollutants and zonal definitions are to be used, and how do emissions interact to determine ambient quality? The effect of emissions on ambient quality is a function of location and geography, timing of discharges, the location of other emitters, and stochastic elements due to weather and other factors. It helps, of course, if the relationship between emissions and ambient quality is approximately linear. It also helps if emissions of key pollutants can be modeled as if they were independent or additive to other key pollutants. Over how large a region should the permit holder be allowed to locate? If the level of ambient water quality is very sensitive to the location of an emitter (not just to the amount of emissions), changes in the location of permits and emissions, with no change in total emissions, may produce significantly different levels of ambient quality. Clearly, a great deal of water quality modeling would be needed to simulate various locational patterns of emissions and the outcomes of different zonal boundaries and temporal patterns. We do not want to make too much of these technical problems because most of them exist under any kind of pollution control scheme. Nevertheless, the significance of possible changes in the spatial distribution of emissions needs to be carefully worked before emission permits can be made fully tradable for a given zone or geographical area.

On the economic side, the requirements are that the market be reasonably competitive. If it is not, it is possible that the efficiency losses from monopoly power either in the sale or purchase of permits will erode much of the efficiency gains of the system. It is also possible that a "thin" market may not generate prices for permits that are sufficiently close to the long-run equilibrium price to encourage either the proper amount of investment in permanent pollution control facilities or the proper number of firms in the area. In theory, a competitive regime of property rights in pollution permits can be shown to have the desirable equilibrium properties. The possibilities of noncompetitive markets and their properties need to be examined before one can fully endorse a scheme of tradable permits. Notice that the zonal definitions in terms of maintaining ambient quality standards may have to be qualified in terms of the requirements of a competitive market. The size and configuration of emission permit regions also will affect the number and size of potential market participants and the equilibrium solution.

With regard to equity, a primary question is the initial distribution of permits. At one extreme is the assumption that the property rights belong to the state and that the best solution is to simply auction off the permits to the highest bidders and let the process begin. This would mean that emitters would pay economic "rent" for permits plus abatement costs. An alternative would be to base the distribution of permits on the pattern of emissions that existed in preregulatory days. Another version of this policy is to make all existing discharge permits tradable. If the relative amount of the emissions were approximately equal across sources and if the number of emitters were large, the chances of achieving prices in the short run that would be close to long-run equilibrium prices would be good. Therefore, rational, long-term investment planning and cost minimizing would be fairly assured. However, if there were one or two large sources of emissions and a group of small emitters, there might be a problem in getting the market started fast enough to give the right signals to firms making location and abatement investment decisions.

Halm and Noll (1981), in investigating a potential market for tradable permits in sulfur oxide emissions in the Los Angeles airshed, identified 30 emitters of consequence. However, one firm had approximately 30 percent of all emissions. The problem they were concerned with was how to organize a permit market with a single large source and yet to try to approximate a competitive outcome. One outcome they investigated was to allocate only a fraction of the permits on a historical basis, say 80 percent, and then let the agency auction off the remainder. Thus, it would be possible under some schemes of permit distribution to place all firms in the position of being buyers, which would nullify some of the market power of the largest firm. Such a scheme would help preserve some equity by giving existing emitters some automatic property rights. This policy might go part way in appeasing municipal dischargers, who might demand special treatment if the auction method were used to vest all initial permits.

Ackerman et al. (1974, p. 275) feel that the tendency to minimize effluent charges across zones by regulatory authorities would be lessened with tradable permits. With a fixed number of rights in each zone, firms located on zonal boundaries could participate in both markets. When it is economical, such firms could buy a permit in an adjacent zone and pipe their wastes to the next zone. The calculation of the "correct" price is done by the market, and the option to pipe wastes to a neighboring zone reduces pressures for plant relocation.

Implementation problems include the length of life of the permit and how to change the number of permits as pollution policies change. The regulatory agency must be careful not to generate uncertain expectations regarding the decision to invest in permits and long-lived capital facilities. When information is imperfect, particularly when first starting a tradable permit scheme, it might be wise to issue permits with varying maturities as Ackerman et al. (1974, p. 268) have suggested. The arguments for moving toward a permanent vesting of rights are very strong. As the benefits of achieving predetermined environmental targets are better understood, the question of whether to change the number of permits can be faced with more information. Most of the monitoring and enforcement problems appear tractable compared with alternative strategies.

Obstacles to Efficient Policy

There are a number of obstacles to the establishment of an effective and efficient water pollution abatement policy. Perhaps foremost is the basic indifference about efficiency in a clean-water program. Unless there is some kind of headline-catching scandal, the fact that billions of dollars are being spent for pollution control facilities without documentation of possible benefits will continue to elicit little public outcry. In addition, there is a widespread notion that water pollution is simply wrong and that it is the role of government to exercise its police power to eliminate all pollution rather than to weigh the benefits and costs of alternative abatement policies. How else can we explain the fact that basic economic analysis has played almost no part in the formulation of water pollution policy? There has been an almost exclusive reliance on detailed federal regulation and judicial enforcement despite repeated criticisms of the inability of the bureaucracy to cope with complex environmental problems. The excellent, well-written critique by Kneese and Schultze (1975) of air and water pollution policies has received little attention by the Congress and the electorate.

Lack of Benefit Estimation

A second major barrier to the achievement of efficiency may stem from the first, but it needs special emphasis. In the discussion of the four steps to measure pollution damages, it was pointed out that measures of damages should be viewed as the benefits from abatement. Without measuring benefits, efficiency cannot be ascertained. Although measures of damages, particularly step four involving dollar valuations, cannot be done easily, we have to go as far as we can. Benefit-cost analysis should not be considered a simple decision rule, but a way to systematically organize information to help make choices about pollution damages and the resources involved in pollution control.

The theory of what and how to measure benefits of water pollution abatement is well understood (Freeman 1979). Currently, we do not have good approximations of the damages caused by pollution in various river basins and major lakes. Empirical estimates of the benefits of water pollution control policy are badly needed. As Freeman suggested (p. 265): "It would be penny-wise and pound-foolish not to plan to allocate 1 or 2 percent of the total funds to be spent on pollution control toward measuring and evaluating what we have bought with that massive expenditure."

Nonpoint Pollution

Nonpoint pollution is perhaps the major challenge facing the cleanup of the nation's water supplies. As earlier pointed out, more than half of all pollutants entering surface waters come from nonpoint sources. It is believed that nonpoint pollution also seriously affects ground water, although systematic data on ground water quality is not available. In contrast to the limited progress that has been made in cleaning up point discharges, progress with nonpoint sources is almost negligible. The most important nonpoint sources of pollution are agriculture, urban runoff, forestry and mining, and individual wastewater disposal (septic) systems.

Agriculture

According to CEQ (1979, 1980) water pollution from agriculture affects 68 percent of all river basins in the United States, with most of the pollution the result of fertilizers, pesticides, pathogens, organic materials, and sediment. Half of the sediment entering surface waters stems from soil erosion from farming, about 3.8 billion tons annually. According to the GAO (1977), soil erosion into streams is 25 percent worse than in 1934 despite conservation efforts. It is believed that 7.5 million tons of phosphorus and 600,000 tons of nitrogen enter surface waters annually. Most agricultural runoff is difficult to manage and can seriously upset ecological balances.

Urban Stormwater

Pollution from urban runoff, a more serious problem than previously recognized, contains heavy metals (lead, zinc, and copper) as well as high concentrations of coliform bacteria, BOD, asbestos, suspended solids, and oil and grease. CEQ (1980) reports that a study of Washington, D.C., found that street runoff contained 104 times as much suspended solids as the effluent from a secondary treatment sewage plant. The lead concentration was 1,015 times greater. Most of the older cities in the U.S. have combined sewer and stormwater collection systems that are a major source of water pollution. The amount of raw sewage and wastes dumped into receiving surface waters during rainstorms may offset sewage treatment in dry weather. Chicago's problems with raw sewage backing up into residences, flooding streets, and pouring into surface waters are well known. The city's tunnel and reservoir plan (TARP) to deal with this problem may turn into one of the most expensive public works projects ever, $11 billion at last estimate. The GAO has recommended that EPA reconsider TARP.

Other Nonpoint Pollution Sources

Septic systems are causing water quality problems in 43 percent of the U.S. river basins. Coal mining leads to sulfuric acid pollution in nearby surface and ground water. Forestry can cause soil erosion and landslides. Runoff from municipal and industrial waste disposal sites is now believed to pollute drinking water sources. One of the chemicals most frequently found in treated as well as untreated drinking water is trichloroethylene (TCE), a widely used solvent and degreaser, which causes cancer in mice.

The dangers of nonpoint toxic runoff has come to light only in the past five years. Yet the seriousness of organic waste pollution has been long established. For example, EPA estimates of total suspended solids and organic waste discharges for the U.S. for 1973 are shown in Table 1. The striking fact about Table 1 is how much the TSS wastes (96 percent) and BOD wastes (82 percent) are dominated by nonpoint sources. Yet EPA for years has granted permits for point discharges of such wastes and supervised a very expensive cleanup process. Of course, national totals can be deceiving. For one thing, nonpoint discharges may be more diffused than point emissions. But from 1975 to 1979 there was little improvement in dissolved oxygen in many surface waters despite the large expenditures and heavy regulation to reduce BOD pollution. If nonpoint sources of pollution are a relatively large part of the problem, how can we expect water pollution control policy aimed at point sources to be effective and efficient?

TABLE 1

EPA ESTIMATES OF U.S. DISCHARGES OF TOTAL SUSPENDED SOLIDS AND ORGANIC WASTE, 1973
(billion pounds)

	TSS		BOD	
Municipal sources	5.9	(0.15%)	5.6	(10.2%)
Industrial sources	117.9	(3.10%)	4.3	(7.8%)
Nonpoint sources	3,698.0	(96.75%)	45.0	(82.0%)
Total	3,821.8		54.9	

SOURCE: Council on Environmental Quality, Seventh Annual Report, 1976, p. 257.

To be fair, the Clean Water Act of 1977 gives EPA no specific authority to regulate pollution from nonpoint sources. EPA is awkwardly trying to deal with nonpoint problems through a Water Quality Management Program known as the "208" plans. The 1972 legislation was largely silent on nonpoint problems. Under 208 plans, states or regional planning agencies must propose "solutions" to regional water quality problems from point and nonpoint sources for both surface and ground waters. This is a tall order. Plus, the plans are not binding on anyone and have been widely criticized for their lack of specificity. The fact is, there are very few obvious solutions for the control of nonpoint runoff. Everyone talks about the need for "comprehensive" and "rational integrated solutions to complex regional water quality problems," but there needs to be more than comprehensive plans and vague references to land management techniques (known as BMPs, or Best Management Practice, in EPA jargon).

Under remedies for nonpoint pollution, CEQ (1980, p. 135) lists only two BMPs — "practices such as soil tilling that minimizes soil erosion in rural areas and street sweeping that minimizes total suspended solids in urban runoff." Funds are being spent by EPA under a Nationwide Urban Runoff Program and a Rural Clean Water Program (with the U.S. Department of Agriculture) to come up with nonpoint solutions. Thus far, the results are far from encouraging.

Economists writing on water pollution have not been able to offer much help either. Direct regulation of sources by licenses, effluent charges, and tradable permits are relatively well examined in the literature, but these techniques apply to point pollution. The common law concept of liability for damages for nonpoint pollution is difficult, if not impossible, to apply when hundreds of nonpoint polluters and parties sustaining uncertain damages are involved. The fact is that the policies applicable to point source pollution appear to have little value for nonpoint pollution problems. It also appears that most economic theorists are unaware of the magnitude of the nonpoint problem.

Kneese and Bower (1968) and Davis (1968) have made a case for regional river basin management of water quality. They believe that such agencies could influence land use decisions to reduce nonpoint pollution. They also advocate instream treatment measures, as opposed to exclusive emphasis on end-of-the-pipe treatment, which may be effective for nonpoint problems. Short of such broadbrush suggestions, we are lift to particularized measures for slowing runoff, such as settling ponds for urban stormwaters or putting up barriers to inflows, like swales around urban lakes or dikes on irrigation drainage canals. It is possible that such practices may have payoffs that are higher than expensive treatment facilities for point emissions. We will never know, however, until we begin to weigh benefits and costs of all of the various abatement alternatives.

Conclusion

This paper examined various pollution abatement strategies as a basis for an efficient water pollution control policy. Particular attention was paid to the present policy of direct regulation and to two untried market approaches, effluent charges and tradable permits. There is a need for an efficient water policy based upon a weighing of benefits and costs. But the question is whether an efficient water pollution policy can really be achieved.

The evidence is fairly clear that the present policy of detailed direct regulation of discharges is expensive, wasteful, and ineffective. Economic concepts have not been employed in the goals being sought or in the instruments being used. No credible estimates of benefits and costs of current programs exist despite the expenditures of billions of dollars. Much more worrisome is that even though these conditions are relatively well known by economists, there is little public concern for efficiency and little effort to change the thrust of water pollution policy by the electorate or by Congress.

Other obstacles to efficient policy are noted. One is the failure to estimate physical damages from pollution in a systematic fashion and the failure to at least attempt to place monetary values on damages averted by pollution abatement. This means that benefits of environmental improvement from water quality are in the realm of conjecture.

Another obstacle stems from the failure to deal with the serious problem of nonpoint pollution. Efforts to deal with water pollution by controlling only point sources cannot succeed. Current U.S. policy as well as the economic literature fail to recognize this problem.

With regard to point pollution, both effluent charges and tradable permits have significant advantages over direct regulation. The use of administered markets can do much to reduce regulatory controls and to allow for more initiative by individual decision-makers to achieve least-cost solutions. In addition, the integration of water law with these market-type solutions promises to strengthen the role of private property and market allocation. The need for public policy in water pollution has arisen because private markets are not working well. Instead of attempting to make markets and the price system work more effectively, Congress has adopted a policy of direct regulation. Effective and efficient water pollution control policy requires a commitment to make greater use of markets and the price system as instruments of social policy. Even more basic, however, is a commitment to a goal of efficiency in environmental policy itself. The obstacles to such a commitment appear formidable.

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Changing the Clean Water Act: reflections on the long-term

With the growing realization that the 1983 and 1985 goals of the Clean Water Act will not be met, several proposals to amend the act have surfaced. Some have merit, but most focus only on short-term solutions. The author concedes the need to fine-tune the basically sound act; however, to reflect the political and economic realities and the technical knowledge that have been gained since the original act was passed in 1972, he offers some long-term proposals. This article was submitted for publication with the stipulation that, if published, the author's name be withheld. In the editor's opinion, the author's professional stature lends credence to the article, but his occupational affiliation justifies his request for anonymity.

A renewed and intense debate over changing the Clean Water Act took place in 1982. Many proposals were offered by a wide variety of interest groups. Agreement was reached, however, only on a few, relatively short-term remedies to obvious problems in the act. At the same time, the U.S. Environmental Protection Agency (EPA) produced an increasing tide of regulatory amendments as the new leadership of the water programs began to exert its influence. The principal theme of the revised regulations was the shift of decision-making responsibility to the states through greater simplification and flexibility of the federal requirements. The fundamental issue of long-term change in Clean Water Act policy, however, remains to be settled in the legislative arena.

In the hope of promoting the public discussion of changing the Clean Water Act, it might be useful to reflect on a few issues and proposals. First, a little history is in order.

Years ago, the federal regulatory and enforcement role was anemic, in deference to a strong dependence on the states for effective enforcement programs. The burden of proof was on the government to demonstrate, first, that the beneficial use designated for a body of water had been impaired and, second, that the impairment was caused by specific individual dischargers. Demonstrating this firm link between cause and effect was the basis for federal enforcement activity. Unfortunately, water quality monitoring networks typically were not designed to isolate and identify the adverse impacts of individual dischargers. In addition, the use of mathematical models was not considered reliable enough to support an enforcement case in court. The result was few federal enforcement actions.

By the late 1960s, however, state control programs were criticized for inaction, lack of personnel and funds, inconsistency, and favoritism toward major industrial dischargers. The response was the 1972 Federal Water Pollution Control Act Amendments, which declared a revolutionary change in policy, from demonstrating cause and effect in the receiving waters to applying technology-based effluent limitations to discharges to the receiving waters. The technology-based effluent limitations were conceived of as the minimum requirements needed to achieve clean water. More stringent controls could be applied on a case-by-case basis, depending on the quality of the receiving waters. Equity was defined in economic terms: the same limitations (and corresponding costs of treatment) for the same type of discharger independent of location (that is, independent of the impact of the discharge on the receiving waters).

Our experience since 1972, however, has uncovered a number of problems requiring adjustment in the act. For example, the emphasis of the 1972 act was on the control of gross pollution caused by conventional pollutants, such as biochemical oxygen demand (BOD) and suspended solids. Since then, more attention has been given to the less obvious, but perhaps more important, low-level toxic and hazardous pollutants. Developing effluent limitations for these pollutants has proven to be much more complicated than for the conventional pollutants. Another example arose from the changes in the economy experienced since 1972. The originally optimistic assessment of national treatment needs as both attainable and affordable in a short period has become pessimistic. There does not seem to be enough money available to achieve the goals of clean water everywhere by 1983, or even by 1990.

It is clear that it is time to update the Clean Water Act. The technology-based approach in the current act contains much that is valid, however, and it is more a time for pragmatic adjustments than for radical revisions. It is important that the basic approach of the act should not be lost in a welter of technical amendments. For example, consider the current strong demand for cost-effective analysis of the impacts of improved treatment on the receiving waters compared with the costs of treatment. This could be interpreted as a means to set priorities and schedules for the use of limited resources, consistent with the long-term goals of clean water everywhere. However, this also could be interpreted as a return to the pre-1972 policy of having to demonstrate cause-and-effect adverse impacts in the receiving waters before improved treatment could be required. We must be careful in our choice of interpretations.

The proposals that follow are intended to contribute to the discussion of Clean Water Act revisions. Their order generally follows the section sequence of the current act. They are neither comprehensive nor complete, but reflect a few key points for the long-term direction of the national clean water program. They also are consistent with the trend toward greater flexibility and responsibility for the states, through program delegation. Of course, greater state delegation implies increased incompatibility of programs across state lines, but the benefits of decentralization seem to be worth the risks, at this point.

Goals of the act

The goals of the Clean Water Act are national statements of purpose. They set the context for the specific programs authorized throughout the act. Unfortunately, the goal of the elimination of discharge of pollutants by 1985 created some confusion in that no program authorized in the act clearly promoted this goal. Dischargers reacted by attacking the 1985 date as an unrealistic deadline, whereas others attempted to defend it. At this point, the confusion could be avoided if the 1985 date were dropped from the act. However, the goal of the elimination of discharge of pollutants should be retained, both as a statement of purpose, and as encouragement for the development of recycle and reuse systems.

Similarly, the interim goal of fishable-swimmable waters cannot be attained by 1983. In this case the date should be extended to provide enough time to construct and implement any new amendments to the act and regulations, operate the large number of new municipal and industrial treatment facilities, and evaluate the resulting trends in receiving water quality. An extension to 1993 would allow for two complete planning and evaluation cycles, as well as a mid-course correction. In this regard, a new National Commission on Water Quality could be established in 1986 to report in 1988 on the state of the nation's waters. The commission would provide an open and formal process for the next mid-term evaluation of the act.

Recognizing these adjustments to the timeframe of the act, it is important to preserve the technology-based approach to achieving the long-term goals. Retreating to a cause-and-effect, receiving waters approach would risk bringing water quality improvement to a virtual halt. In spite of recent technical improvements in analytical methods and in model sophistication, it remains difficult to prove that a particular discharge caused a particular adverse impact in the receiving waters. This is especially significant in trying to determine the long-term, chronic impacts of toxic chemicals. If cause-and-effect were a prerequisite for remedial actions, then there again would be few such actions.

One means to preserve the technology-based approach would be to make this philosophy an explicit part of the context of the entire act. Accordingly, the section on goals should establish a national policy that ensures progress toward the goals of the act be achieved through programs designed to reduce or eliminate the discharge of pollutants to the waters of the U.S. Such a statement would make it clear that all dischargers have the general obligation to reduce or eliminate their pollutant discharges. It also would provide the policy context for the National Pollutant Discharge Elimination System (NPDES) permit program.

On the other hand, it has become obvious that requiring treatment without any consideration of environmental benefits sometimes does not result in the wise investment of scarce resources. The current programs clearly have forced some industries and municipalities to build treatment facilities that reasonably cannot be justified in terms of their beneficial impacts on water quality or the broader environment. One example is the provision of secondary treatment for discharge into an intermittent stream with no designated beneficial uses. Another example is a pretreatment requirement for a small industrial discharge into a large municipal system. Like it or not, municipal sewers in fact provide the benefits of dilution in that many pollutants simply are not detected at significant concentrations at the treatment plant. Under such circumstances, pretreatment may not be a high priority. As these examples illustrate, uniform effluent limitations are not always appropriate or reasonable.

What is needed is an attempt to balance the technology-based approach with a recognition that not all receiving waters were created equal in their ability to assimilate pollutants. In some locations, for example, it may be possible to achieve the goals of the act with less stringent treatment requirements. Given this perspective, equity no longer would be defined as equal treatment for equivalent dischargers. The new definition of equity would provide for similar receiving waters with equivalent designated beneficial uses to be given equivalent levels of protection, using technology-based controls to achieve that goal. This balanced approach could be added to the Title I goals of the act by establishing a national policy to classify the waters of the U.S. either as attainment or non-attainment areas with respect to the goals of the act. The key point is that different levels of technology-based controls would be applied to each category of receiving waters. This approach will be discussed in more detail later.

State program grants

The current policy on state program grants seems to create a dilemma. On the one hand, the states are encouraged and expected to assume increased responsibilities through assumption of delegated authority for more federal programs. On the other hand, proposals are made that recommend immediate and substantial reductions in federal appropriations for state program grants. Although it may be easy to assume that the states voluntarily will pick up the increased financial share, this assumption avoids the current realities of general state budget cuts. Alternative sources of funds for the states, such as permit fees, may take several years to develop through the state legislative process, if at all. Thus, it seems likely that short-term reductions in state program grants will result in the return of delegated programs from the states to EPA. If this occurs, the reduced staffing and budget levels at EPA would guarantee that the programs would not be administered effectively.

State program grants can be interpreted as inefficient gifts that weaken state self-sufficiency by prolonging a dependency on federal funding. Alternatively, state program grants could be viewed as contracts for services to meet the national program goals. The latter approach seems to be more consistent with an interest in effective state water programs. Therefore, it is reasonable to recommend that appropriations for state program grants be maintained on a constant-dollar basis through 1993, to provide enough time for the states to develop their own alternative sources of funds.

A related issue involves EPA's research and development (R&D) program. Many have said that EPA's R&D priorities often are not relevant to regional or state program needs. Short-term and applied research generally has been ignored in favor of long-term basic research. If R&D is to support the national water programs and if most of the programs are being delegated to the states, perhaps it is time to stop treating R&D as an independent EPA program. It might be more practical to delegate most of the R&D program to the states through their program grants. The EPA role would be to conduct R&D where needed to support the national programs, such as in developing regulatory standards, and to review and coordinate state R&D activities. EPA would set national priorities, serve as a clearing house for research reports, and screen R&D projects to avoid unnecessary duplication of effort.

Construction grants

As EPA's largest program, the wastewater treatment construction grants program has been under continuous review and criticism. Some $38 billion (through 1982) has been invested in municipal treatment plants since 1972, but the bulk of that investment will not be operational for another 2 or 3 years. Even though the full environmental impact of the construction grants program cannot be measured yet, many changes to the program and its regulations have been made, and continue today.

Unfortunately, most of the discussion on the construction grants program has focused on short-term problems, tinkering with the program while ignoring the fundamental issue. The long-term question is how to assure a self-sustaining capacity to build for growth and to rebuild for replacement of municipal wastewater treatment systems.

Few today believe that the federal grants will continue for more than another 5 to 10 years. EPA has even proposed terminating the grants after fiscal year 1985. Assuming, however, that full agreement is reached on an annual appropriation level and on a firm termination date for the federal grants program, the long-term question still would remain, and the nation's municipal treatment needs would not have been met. The point is to address what will happen 10 to 20 years from now, when the plants built with federal grants begin to wear out. At that time, it is no more likely that local governments will have been able to accumulate the large reserves needed for replacement than has been the case to date.

Where then will the nation obtain the funds for the enormous growth, rehabilitation, and replacement needs that are inevitable? In this long-term perspective, the construction grants program clearly has been a necessary, but temporary, first phase that has bought time for the nation to address the long-term question. Many alternatives have been advanced to answer this question of long-term funding. Assuming that it is desirable to internalize program costs by having the users pay directly for services received, the following is an approach to a solution.

Large municipalities, or groups of cities voluntarily associated through regional treatment systems, should be encouraged to provide wastewater treatment services as public utilities. In this manner, as for electric, gas, and telephone services, the reserves needed for growth and replacement can be built into the rate base and collected in the monthly user charges. Grants to develop and establish these municipal utilities should be made an eligible construction grant item. The Clean Water Act could provide for an initial grant to cities for 2 years, with annual continuation of funding conditioned on a demonstration of reasonable progress. In no case should such utility development grants extend past 5 years.

Smaller municipalities, however, may not be able to form self-sufficient utilities at reasonable levels of user charges For this large group of municipalities, the state could serve as the common utility through a revolving trust or loan fund. Participating municipalities would contribute a portion of their monthly user charges to the fund, thus guaranteeing the long-term availability of capital for their projects.

However, federal incentives might be needed to stimulate the creation of revolving funds by the states. Some possibilities for incentives include the following. The first 1 or 2 years of capital for the revolving funds could be provided by federal appropriations, as part of the sunset of the construction grants program. Concurrently, the states should be required to assume and maintain program delegation to be eligible for the capital funding. State priority systems would be used to allocate the funds each year. Finally, participation in the revolving fund and adherence to priority system planning, design, and construction schedules generally should insulate the municipalities from federal enforcement action. Authority to override state priority decisions and schedules should be exercised by EPA only after consultation with the state, after an opportunity for a public hearing for the municipality, and if reasonable progress is not being made toward the water quality goals.

Adoption of the municipal utility and state revolving fund approach offers a clear opportunity for state and local self-sufficiency. If this opportunity is missed, and a dependence on the federal level continues, then there remain other alternatives to the present grant program. One alternative for large municipalities would be single-project federal public works authorizations, such as are used for dams and water reclamation projects. The authorization would cover the 5 to 10 years needed to complete the project, subject to the annual congressional appropriation process. After completion, the projects would be turned over to the municipalities for operation and maintenance, and repayment of the funds on a long-term, low-interest basis. One alternative for the smaller municipalities would be to authorize their projects as public sector jobs projects. This approach would recognize the growing need to rebuild America, as well as to provide some relief to the currently high levels of unemployment. Again, the costs could be repaid on a long-term, low-interest basis.

Finally, because this discussion has been more illustrative than exhaustive, many other options should be examined. If no agreement is reached this year at the national level, then at a minimum EPA could provide grants to the states to assist them in developing more appropriate fiscal and institutional alternatives to the construction grants program.

Planning

The discussion of revising the goals of the act noted the need to attempt to balance the technology-based approach with a recognition for the assimilative capacity of the receiving waters. Such a balance might be obtained by following the model provided by the Clean Air Act. That is, the states could be required to designate the various segments of their receiving waters either as attainment or as nonattainment segments with respect to the interim goal of fishable-swimmable waters.

The designation of receiving water segments could be categorized either by individual pollutants or by groups of pollutants, depending on the beneficial uses to be protected. For example, a segment could be classified as attainment for the conventional pollutants, and as nonattainment for toxic pollutants. Each state would be allowed to develop its own system of designation procedures and categories, subject to public hearings and EPA review and approval.

Available data should be used to avoid significant delays in the designation process. In addition, because a great deal of judgment would enter into the segment designations, the state procedures would have to provide ample opportunity for public comment. Updates every 5 years would allow for new data from ongoing monitoring programs to refine the original designations. The first round of designations could be completed within 2 years, and would provide the basis for applying the different levels of technology-based standards.

Discharge standards

Dischargers affected by the regulatory provisions of the Clean Water Act currently face a bewildering array of deadlines and terminology. Is the deadline 1977, 1983, 1984, 1988, or just 3 years after the final regulations? Is the requirement for best practicable technology (BPT), best available technology (BAT), best conventional technology (BCT), or simply best professional judgment (BPJ)? Which definition of secondary treatment applies? Obviously, there is a need to simplify the regulatory scheme of the act.

First, the deadline to achieve the interim goal of fishable-swimmable waters could be revised to 1983 for all dischargers, as discussed earlier.

Next, in considering revisions to the treatment requirements of the act, perhaps it is time to acknowledge that a great deal of pollutant discharge reduction already has been accomplished. Perhaps forcing all dischargers to install secondary treatment or BAT is more stringent than is necessary to meet the goals of the act.

The segment designation process provides one means of recognizing and giving credit for the progress made in the past 10 years. If a segment can be classified as having reached attainment, then there should be no need to require more stringent treatment by its dischargers. In such a case, more stringent requirements indeed would be treatment-for-treatment's sake. Because of what we know today, it may be possible to achieve the interim goal of fishable-swimmable waters with less stringent treatment requirements than were anticipated in 1972.

Given that perspective, the act could be modified to provide that the minimum treatment requirements for segments classified as attainment be the equivalent of BPT for industrial dischargers, and of intermediate secondary treatment for municipal dischargers. Further, the minimum requirements for nonattainment segments should be the equivalent of BAT for industrial dischargers and of full secondary treatment for municipal dischargers. In this scheme, of course, BAT must be defined as more stringent than BPT. Even more stringent treatment requirements could be imposed by the states, based on wasteload allocations and associated cost-benefit analyses for nonattainment segments. Less stringent requirements, including so-called backsliding by existing dischargers, could be justified by following the provisions of Section 301(g) of the act, which allow for case-by-case waivers on a showing by the discharger that the goals of the act still would be met. Emphasis should be placed on the requirement for the discharger to bear the burden of proof in such cases, through a process that includes public hearings and EPA review and aproval of state determinations. Attainment of the goals would be defined as meeting the specific water quality criteria adopted by the state to protect each designated beneficial use, at the edge of a well-defined mixing zone.

The establishment of different minimum treatment requirements for attainment and nonattainment segments represents one attempt to balance the technology-based and water-quality-based philosophies. The language may seem to be foreign to the Clean Water Act, but the precedent already exists in the Section 301(h) modification for municipal discharges to the ocean. This provision essentially recognizes that, if properly dispersed, conventional pollutants from municipal discharges will not cause a water quality problem. In the language used here, Section 301(h) implies that the ocean generally is an attainment area for conventional pollutants, and, correspondingly, that the minimum treatment requirement for the ocean should be intermediate secondary. Most smaller municipalities discharging principally conventional pollutants with adequate dispersion should be able to qualify for the less stringent treatment requirement. The situation may be different, however, for larger municipalities with significant industrial wastewater contributions to their systems. The ocean could be adversely affected by the low-level toxic and hazardous pollutants in such discharges and classified nonattainment. Therefore, the Section 301(h) regulations have been designed to assure an adequate demonstration that municipal discharges will not impair the beneficial uses of the receiving waters.

Water quality standards

Ideally, water quality standards define the interim goal of fishable-swimmable waters for each segment of the waters of the nation. Each standard consists of designated beneficial uses and of pollutant-specific numerical criteria intended to assure attainment of those uses. Unfortunately, most existing standards include criteria only for the conventional pollutants and a few of the common toxic metals. It has not been clear whether and how the standards could be amended to address the long list of hazardous and toxic pollutants that might prevent attainment of the designated uses.

It would be administratively burdensome for each state to adopt criteria for each of EPA's priority pollutants. Moreover, the hundreds of other potentially toxic pollutants for which the criteria data base is not adequate also could interfere with attainment of the beneficial uses. How, then, can the existing water quality standards be improved?

One means of addressing the adverse impact of hazardous and toxic pollutants would be to rely on the general language in the standards that prohibits the discharge of toxic pollutants in toxic amounts. The standards could be supplemented by including a requirement for periodic bioassays to identify the presence of toxic pollutants not covered by the adopted criteria. The bioassays would be conducted both on the receiving waters and on the point-source discharges that are suspected of discharging the toxic pollutants. Such a screening technique would focus resources on the nonattainment segments and provide a means to develop site-specific criteria for identified toxic pollutants.

EPA's role would be to develop and publish criteria guidelines as appropriate information becomes available. The states would update their water quality standards every 5 years, prior to updating their attainment/nonattainment designations. EPA would review and approve each amendment to the standards.

The continuing planning process

The continuing planning process should provide each state with a management system for integrating the various planning, grant, and enforcement mechanism of the act. Unfortunately, the process seems to have deteriorated into a routine listing of activities without a coherent sense of purpose. One remedy would be to focus the continuing planning process more precisely on the interim and long-range goals of the act.

The major documentary output of the continuing planning process should be a periodic report describing the state's progress toward meeting the goal's of the act. Every 5 years the report would combine the data base and trend analysis of the Section 305(b) report, with a management strategy analogous to that of the air program's State Implementation Plan. Progress toward the goals would be measured both by water quality trends in terms of the conversion of nonattainment into attainment segments, and by technology-based trends in terms of net pollutant removals.

The management strategy would allow each state the flexibility to determine what, how, and when each control mechanism of the act would be used to achieve the goals. Most importantly, this implementation plan approach would allow each state to evaluate and trade-off control programs, such as point-source versus non-point-source controls, municipal versus industrial effluent standards, and pretreatment versus end-of-pipe municipal treatment levels, in developing cost-effective, state-specific strategies. As an example, this approach would allow a state to determine that it is a higher priority and of greater water quality benefit on a given segment to tighten an industrial effluent standard than to upgrade a nearby municipal discharge to advanced treatment. In this manner, the increased state flexibility could result in a generally more cost-effective water pollution control program.

Enforcement

The current enforcement provisions of the Clean Water Act have been reasonably effective and should be retained. In several respects, however, the enforcement program would be strengthened by expanding the range of options available to the states and EPA.

One new option arises from considering the lesson of public water supply compliance under the Safe Drinking Water Act: dischargers could be required to issue public notices of significant violations of their permit requirements.

Another option arises from the recognition that imposing fines on violators only through the courts or through court-enforced consent decrees is both time-consuming and formally adversarial. The states and EPA should be able to assess fines administratively. This option would promote the speedier settlement of cases, provide greater leverage for the agencies to negotiate settlements directly, and reserve only the most serious cases for the courts.

A final option relates to the conflicting roles played by EPA with respect to municipal enforcement. Federal funding through the construction grants program has tended to undermine enforcement through a concern for equity. That is, why should municipalities on the state priority lists receive 75% federal funding while those of lower priority are forced to proceed at 100% local cost? If the construction grants program indeed is not funded past 1985, or even if it continues at the same inadequate appropriation level, then the historic, inhibiting connection between grants and enforcement will be greatly weakened. If, at the same time, states do not promptly develop the long-term independent financial programs discussed earlier, the need for effective municipal enforcement will grow.

The principal enforcement mechanism that has been missing from the Clean Water Act is the ability to impose bans administratively on new connections to municipal waste treatment systems. Connections bans would avoid the cumbersome court process while providing a strong economic incentive to municipalities to reach rapid negotiated settlements with the regulatory agencies.

New incentives

Rather than end this discussion on the negative note of stronger enforcement against recalcitrant industries and municipalities, it is preferable to conclude with some positive notes on incentives for progressive performance. The following concepts not now in the Clean Water Act use economic incentives to promote improved water quality for the nation.

The first such concept involves protecting the immense capital investment being made in municipal wastewater treatment plants, an effort that requires a sustained level of proper operation and maintenance (O&M) of these plants. One way to stimulate better O&M would be to modify the revolving trust or loan funds, which provide capital support, and also to provide for revolving O&M incentive payments. A participating municipality would receive annual payments from the fund if its effluent quality consistently was better than required by its permit. Conversely, the municipality would agree to contribute to the fund if its effluent quality exceeded its permit limits.

A second way to stimulate better O&M would be to hire consultants as circuit riders to provide technical assistance to municipalities in diagnosing problems and in recommending measures to improve plant performance. Circuit rider financing could come, in whole or in part, from state or federal grants, or from the state revolving funds. In any case, the small amount of money invested in prevention through improved O&M would save a great deal in deferred or avoided capital expenditures.

The second concept involves supporting the states in their implementation of the integrated continuous planning process. First, the various categorical grants could be combined into a single state water quality management grant. The categorical funds then could be mixed and expended according to the priorities established in the state water implementation plans. Second, a bonus of up to 10% of the annual state grant could be given for outstanding performance, as defined and committed to in the annual state work plan. Both of these incentives would support strong state performance by backing state priorities with federal funds.

The third concept involves reducing the potential for toxic pollutants to be discharged to the receiving waters. Seed grants would be made to the states for a 2-year period to establish and contract for private management of industrial residuals exchanges. After the initial period, the exchanges could be supported by a combination of state, local, and industrial contributions. This concept would enhance state management of many toxic and hazardous materials, reduce demands on the limited space available in existing hazardous waste landfills, and promote the goal of recycle and reuse.

The fourth and final concept involves the need to stimulate innovation in the entire field of water quality management. EPA could sponsor an annual national innovative technology and management competition for the private sector. Independent panels would act as judges in the various categories, such as planning, standards, treatment technology, monitoring, and so on. The competition could provide both national publicity and substantial cash awards for the best proposals. In this way a relatively small annual investment at the federal level could do much to promote innovation in the private sector.

Conclusion

This paper has provided a number of suggestions for amending the Clean Water Act. The intent was to stimulate discussion as Congress continues its oversight and reauthorization process. The discussion also was intended to stay within the spirit of deregulation, the simplification of federal programs, increasing delegation of responsibility to the states, improving the cost-effectiveness of federal-state programs, and using economic incentives to supplement the regulatory approach.

The dates in the box represent an attempt to tie together the principal concepts discussed into a 10-year schedule for the amended water quality management process. With luck, and considerable assistance from other interested people, the parts will combine into a coherent whole during the next year.

In conclusion, there is no better time to rethink our approach to achieving improved water quality throughout the nation. This can be a time of opportunity, rather than despair, in our water pollution control programs. With an eye on the long-term, amending the Clean Water Act can be both a pragmatic and a productive enterprise.

Timeframe for implementation of the principal proposals

Year	Milestone
1983	Establish the policy that progress toward clean water shall be achieved by reducing or eliminating the discharge of pollutants.
1984	Update water quality standards.
1985	Classify waters into attainment or nonattainment segments for the interim goal of fishable-swimmable waters.
1986	State reports on progress toward the interim goal. Implement state alternatives to the federal construction grants program. Create new National Commission on Water Quality.
1988	Report by National Commission on Water Quality.
1989	Update water quality standards.
1990	Update attainment/nonattainment classifications.
1991	Update state reports on progress toward the interim goal.
1993	Achieve the interim goal of fishable-swimmable waters. Terminate federal program grants to the states.
Long-term	Maintain goal of elimination of discharge of pollutants.

Waste Treatment: Doing What Comes Naturally

By taking advantage of nature's recycling systems, cities can reduce the steadily increasing cost of treating sewage while putting this "resource" to productive use.

BY ROBERT K. BASTIAN AND JAY BENFORADO

Some 15,000 municipal sewage-treatment plants in the United States handle more than 26 billion gallons of wastewater each day, serving about 150 million people and at least 87,000 industries. Much of the treated wastewater—called effluent—flows after treatment into streams, lakes, and coastal waters—often to their detriment. The treatment plants also generate more than 17,000 tons (dry weight) of sludge, the solid material removed from the wastewater, every day. Sludge has traditionally been disposed of by incineration, burial in landfills, land application, and ocean dumping. But each option poses environmental concerns and economic barriers that in turn pose serious problems for many communities.

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What's more, both wastewater and sludge are steadily increasing in quantity. This is because population is growing, municipal treatment plants are serving more industries, and federal and state regulations require more thorough treatment of sewage. Treatment plants in 1985 will handle about 15 percent more wastewater and sludge than they did in 1980, and treatment and disposal will also cost more as the prices of labor and energy continue to rise. At the same time, water pollution remains a serious national concern, and supplies of fresh water for irrigation, recharge of groundwater, and industrial and municipal uses are becoming scarce in some regions of the country.

Ironically, we can alleviate such problems by looking at municipal wastewater and sludge as valuable resources. By adopting "natural" treatment systems, many communities can handle their sewage more economically while recycling and reusing the materials productively. These materials are rich in important nutrients: a year's worth of treated wastewater and sludge contains an estimated 1.4 million tons of nitrogen, 300,000 tons of phosphorus, and 600,000 tons of potassium. This represents roughly 10 percent of the amounts of these nutrients now supplied by commercial fertilizers—worth about $950 million at current prices.

Wastewater and sludge also contain many micronutrients that are essential for plant growth, organic matter that is valuable as a soil conditioner, and enough water for one-sixth of the nation's irrigated land. In many cases, the "products" of natural waste-treatment systems can be used to improve farmlands, reclaim strip mines and other disturbed lands, create new recreational areas, recharge groundwater supplies, and produce marketable crops—all of which can help offset treatment costs.

The challenge is to learn how to manage natural ecosystems so that they can safely and effectively assimilate and recycle sewage wastes. With better understanding of how ecosystems function, we can also develop "artificial" natural systems that capitalize on the capabilities of these same processes. Some natural treatment systems are already widely accepted, and many others are being investigated in the United States and abroad. They make use of a diversity of ecosystems, including farmlands, forests, ponds, and wetlands, and they range from variations on traditional land-treatment concepts to intensive aquaculture systems.

Back to the Land

Applying wastewater and sludge to the land has evolved from the time-honored practice of recycling animal manures and agricultural residues. There are three major types of land-treatment systems for municipal wastewater.

☐*Slow-rate land treatment.* Similar to conventional crop irrigation, this relatively popular alternative recycles nutrients and produces a potentially marketable crop while reclaiming wastewater. Partially treated wastewater is applied to vegetated lands, and the soil, plants, and microorganisms clean the water as it soaks in and gradually percolates to the groundwater. Systems used to irrigate farmlands, old fields, and forests are currently operating successfully in many parts of the country.

For example, Clayton County, Ga., located just south of Atlanta, recently started up a slow-rate system that will treat 20 million gallons of wastewater per day by applying it to a 2,400-acre forest of loblolly pines. Costing $43 million to construct, it is one of the largest systems operating year-round. The forest is divided into seven sections, and the water is sprayed through a network of sprinklers. Once a week, each section receives 2.5 inches of wastewater over a period of 12 hours. The trees, to be sold as pulpwood to help offset operating costs, will be harvested on a 20-year rotation cycle. Since the forest is located in the community's watershed, the wastewater eventually becomes part of the drinking-water supply. Other relatively large slow-rate systems—each treating more than 20 million gallons per day—have been installed in Michigan and Texas, while smaller systems operate in at least 40 states.

☐ *Rapid infiltration.* This system is usually used independent of agriculture and forestry operations. Wastewater is cyclically applied to basins containing coarse, highly permeable soil. Physical, chemical, and biological cleaning occurs as the wastewater drains through the soil to the groundwater. (All land-treatment systems use alternating wet and dry periods; this schedule optimizes microbial activity, prevents waterlogging and keeps the soil from becoming clogged with suspended solids.)

Rapid-infiltration systems are gaining in popularity but are still less widespread than slow-rate systems. They are somewhat more limited than slow-rate systems by the need for highly permeable soils and certain underground drainage patterns. Phoenix now uses a large system of this type, while smaller systems are operating in at least 24 states, including New York, Massachusetts, and New Jersey.

☐ *Overland-flow land treatment.* Wastewater is applied at the top of grassy slopes, which are underlain by a relatively impervious soil layer. The water flows in a thin film down the slope and is cleaned by the soil, vegetation, and microorganisms at the soil surface. The water is collected in open ditches at the bottom for reuse or discharge to surface waters. The slopes must be steep enough to prevent "ponding" of the runoff, yet gentle enough to prevent erosion and allow the water enough time to be purified. The slopes must also be carefully graded and kept free from gullies to prevent channeling and allow uniform distribution of the water over the surface. Naturally rolling terrain is easily adapted to the network of slopes and terraces needed for an overland-flow system, minimizing land-preparation costs. Cities can install such systems to preserve green belts and open spaces. In other locations, the systems may be used to produce forage grass for feeding cattle. Perennial grasses with long growing seasons, high moisture tolerance, and extensive roots are best for this purpose.

The city of Davis, Calif., has installed one of the largest municipal overland-flow systems, which treats about 5 million gallons per day. Smaller or experimental systems are operating or are under construction in at least 15 states, including New Hampshire, South Carolina, Mississippi, Texas, and Illinois. The first systems were built in relatively warm climates, but recent advances in construction and design and greater operating experience have made them useful in cooler regions as well. Although overland flow has only recently been used to treat municipal wastewater, such systems have proved their worth in treating food-processing wastes for over 25 years.

Land-treatment systems can clean wastewater to a purity that equals or exceeds some of the most sophisticated conventional treatment processes. The systems also cost less to build and operate than more highly engineered systems—if enough land is conveniently available at reasonable cost. For small treatment plants handling less than 1 million gallons per day, a 25 percent savings in construction costs and 50 percent savings in operation and maintainance costs (partly because they use much less energy) have been fairly common. In larger metropolitan areas with very large volumes of wastewater, these systems may be less practical because of land availability problems. However, large slow-rate systems may be attractive in regions where water is needed to irrigate crops. A slow-rate system usually requires 50 to 500 acres per million gallons of wastewater handled daily. Rapid-infiltration and overland-flow systems require 2 to 50 acres and 15 to 100 acres per million gallons a day, respectively. Both the land requirements and performance of similar projects can vary considerably due to local factors such as soil properties, wastewater characteristics, application rates, crops grown, climate, and the desired level of treatment.

Turning Sludge Into Gold

Processing and disposing of sludge frequently accounts for 50 percent or more of the costs of operating a typical sewage-treatment plant. And with the usual disposal methods limited by lack of acceptable sites, rising costs, environmental problems, and legal restrictions, some communities have turned from a philosophy of disposal to one of reuse. Indeed, about 20 percent of the nation's sewage-treatment facilities currently rely to some degree upon land application as a sludge-management practice. Sludge reuse projects are underway in many large metropolitan areas, including Milwaukee, Chicago, Denver, San Diego, Seattle, Philadelphia, and Washington, D.C., as well as in thousands of smaller cities and towns across the country, especially in the Midwest. The sludge is being recycled as a soil conditioner and organic fertilizer on cropland, pastures, sod farms, golf courses, parks, forests, and disturbed areas.

Raw sludge is 96 to 98 percent water; only 2 to 4 percent consists of solid material. It contains many microorganisms that can cause disease and material that can produce objectionable odors. Therefore, the sludge usually must be processed to "stabilize" it before it is applied to land. Sludge can be stabilized in a variety of ways, including composting, heat treatment, and digestion. "Anaerobic" digestion, in which sludge is decomposed by bacteria in the absence of oxygen, is the most widely used.

Stabilized liquid sludge can be sprayed directly onto the soil surface, incorporated into the upper soil layer by plowing, or injected beneath the soil surface with specially designed injection systems. However, sludge is frequently "dewatered" in drying beds exposed to the sun or with the aid of vacuum filters, centrifuges, filter presses, belt presses, and even thermal dryers. This concentrates the sludge solids and

Federal Policies: From Add-On to Innovative

MANY municipal sewage collection and treatment systems were built in the late 1880s and early 1900s, primarily to protect public health. These plants usually provided "primary" treatment to remove large objects, floating materials, and settleable solids in the raw sewage.

Later, as the public grew increasingly concerned about environmental problems, cities in heavily polluted areas gradually turned to "secondary" treatment as well. These plants use physical, chemical, and biological processes to break down organic matter and remove many of the suspended particles left after primary treatment.

Most communities are now required by federal and state regulations to provide secondary treatment. And in recent years, some communities have been required to do even more. "Advanced" or "tertiary" treatment goes after compounds dissolved in wastewater. These range from various nitrogen, phosphorus, and other inorganic chemicals—which, if discharged in large quantities, can cause rampant growth of algae or other water-quality problems—to an ever-increasing number of synthetic organic compounds including PCBs and pesticides.

During most of the last 10 years, the U.S. Environmental Protection Agency (EPA) has pursued a "technology-based" approach to controlling water pollution. Municipalities and industries have been required to meet specific levels of wastewater treatment and to use certain kinds of treatment processes. However, the emphasis on "add-on" technologies to achieve incremental improvements has locked many communities into costly, relatively inflexible, technologically complicated systems.

Many of these systems use large amounts of energy—the treatment plant in a small town may require more energy than any other public service—while energy costs have more than tripled since 1970. Cities have had problems disposing of the large quantities of sludge that result when wastewater is treated to ever higher levels of quality. And conventional treatment plants often don't perform as well as they should because of low budgets, negligence, and poorly trained operators.

Technology in Flux

The increasingly stringent water-quality standards established in the 1970s, together with the massive infusion of federal funds to help achieve these standards, resulted in one of the government's largest public-works programs. The EPA has provided more than $28 billion through its construction grants program to help municipalities build new treatment plants or improve existing facilities. Most of these plants used conventional technologies. However, the Clean Water Act of 1977 attempted to change this picture.

The act clearly established Congress' intent to encourage innovative and alternative (I/A) wastewater-treatment technologies. More attention and resources were to be directed toward developing processes with "breakthrough potential" in terms of cost reduction, reduced sludge production, improved efficiency, and conservation of resources. Natural treatment systems—including land application and aquatic systems—are ideally suited to meeting these goals.

The EPA defined "alternative" technologies as *proven* methods and "innovative" technologies as methods that advance the state-of-the-art but that have not been fully proven. Only after EPA received such explicit direction by Congress were these "recycle/reuse" technologies looked at seriously by most engineering consultants and the regulatory agencies.

Congress provided strong economic incentives through EPA's construction grants program. A city choosing an alternative or innovative technology could receive up to 85 percent funding of the costs for design and construction of the facility. A city choosing conventional treatment was originally limited to 75 percent, and recent amendments to the Clean Water Act may reduce the funding level to 55 percent or even less. Mindful of a major concern expressed by many city officials and consultants, Congress also allowed the government to pay all eligible expenses to modify or replace I/A facilities should they fail.

The government has funded EPA's construction grants program through fiscal year 1983, but what will happen after that is uncertain. For each of fiscal years 1982 and 1983, a minimum of $816 million is available nationally for I/A facilities. The total construction grants program, including funds for conventional treatment plants, amounts to $2.4 billion for each of these years.

During the program's first three years, more than 800 facilities incorporating I/A technology received federal funds. About 200 of these are "innovative," using more than 60 types of technologies for treating wastewater and managing sludge. These range from conventional systems partially powered by solar energy or heat pumps to overland-flow land treatment, wetlands systems, and aquaculture operations.

The "alternative" projects involve various land-application systems for treating wastewater, land application and composting of sludge, systems that efficiently burn sludge and recover energy, and on-site systems as alternatives to centralized collection and treatment of household wastes.

Many of the I/A projects are still under construction or in their first year of operation, but the program appears to be producing successful projects. For example, 11 of the 72 I/A projects completed in 1982 were chosen as finalists in the American Consulting Engineers Council's 1982 awards program for engineering excellence.—*R.K.B. and J.B.* ☐

lowers transportation costs. Once the dewatered sludge is spread on the soil surface or mixed in, natural biological systems take over, breaking down the sludge and incorporating its nutrients and organic matter into the soil.

Sludge is most commonly applied to agricultural land. Many farmers long ago discovered the benefits of participating in sludge-reuse programs—their fertilizer costs decrease, crop yields increase, and soil quality improves. For example, municipal sludge from several Ohio cities is currently being supplied to farms in neighboring counties, under the direction of the Ohio Farm Bureau and other agricultural groups. Under a grant from the U.S. Environmental Protection Agency (EPA), researchers are measuring the resulting effects on crop yields as well as monitoring human and animal health. Improvements in yields and the lack of health effects noted so far have stimulated greater interest among both farmers and county agricultural extension agents. With success stories becoming more common, farmers may someday routinely approach municipal treatment plants to *buy* sludge for use as organic fertilizer.

There is also growing interest in the potential for using sludge to increase productivity in forests and reclaim damaged lands. For example, researchers in the Pacific Northwest applied about 40 tons of sludge solids per acre to a 50-year-old stand of Douglas fir located on relatively poor soil. Two years later, they recorded a 60 percent increase in growth over untreated sites, resulting in an extra $270 worth of timber per acre. The researchers also predict that the improvement in productive capacity of these forests will last at least five years and possibly longer. Sludge can benefit intensively managed tree "plantations" as well, often dramatically. At the Savannah River Laboratory near Aiken, S.C., researchers have found that applying sludge to loblolly pines may mean that three cuttings of pulpwood—rather than the normal two cuttings—can be harvested in a 20-year period.

However, not all species of trees appear to respond equally well to sludge. Red cedar and hemlock seedlings show high mortality rates when planted on recently treated sites, while Ponderosa pine seedlings survive but their growth doesn't increase significantly. Grasses and weeds in newly clear-cut areas, as well as low-growing "understory" plants in established forests, also grow more rapidly when sludge is applied. Thus, unwanted plants may have to be controlled to reduce competition with tree growth.

Compelled by the federal ocean dumping act to curtail disposing of sludge in the Atlantic, Philadelphia developed a master plan for managing sludge in 1975. The plan included using sludge to revegetate strip-mined lands, and the city is now reclaiming numerous spoil sites in western Pennsylvania. Because of initial opposition in mining areas, the city began with a pilot project, combined with a public-information program, to show local communities that the method was environmentally sound.

In June 1978, the state approved the application of sludge to a 10-acre barren site in Somerset County. Following grading and liming, 50 to 60 tons per acre of sludge solids were spread and mixed into the soil. The area was then seeded with a mixture of grass and legumes, and a lush green plant cover grew rapidly. Researchers monitored sludge, soil, and groundwater before, during, and after application, turning up no adverse effects on the environment. The city has since expanded the operation each year. About 1,100 acres were reclaimed in both 1981 and 1982, using nearly 140,000 tons of sludge annually.

The need for reclaiming abandoned strip mines is great—there are more than 250,000 acres of despoiled lands in Pennsylvania alone and several million acres nationwide. The costs of transporting sludge for such projects—a potential drawback—can be minimized by "backhauling" the sludge in the same trucks or railcars that bring coal from the mining areas to the city. Chicago, Birmingham, and Seattle are already using sludge to reclaim despoiled lands, while Knoxville, Pittsburgh, Tulsa, Baltimore, and several other cities are seriously considering similar sludge-management programs.

Sludge can also be put to good use at home, and one of the oldest sludge-reuse operations is run by the Los Angeles County Sanitation Districts. More than 100 tons of solids per day are composted after stabilization by digestion. The compost is then sold to a local company that screens, blends, and bags the material. The company, which has been in business for over 50 years, markets the sludge-derived product for home garden and horticultural use and to commercial nurseries. Demand is so great that the company must ration the material among selected customers.

While the benefits of recycling municipal sludge are well documented, there are also a number of concerns, especially for agricultural use. Most important is the possibility that pathogens or toxic chemicals that may be present in the sludge may contaminate the soil. If such contaminants accumulate beyond the soil's ability to assimilate them, the land could deteriorate rather than improve, groundwater quality could be degraded, surface water could be jeopardized, and crops could become unfit for consumption.

Researchers across the country have been developing management practices to help prevent such problems. Federal and state agencies, along with a number of universities, have issued detailed guidelines on the proper use of municipal sludge as a soil conditioner and fertilizer. For example, many sludges—especially those from treatment plants in heavily industrialized areas—contain elevated levels of heavy metals such as cadmium and lead and toxic organic chemicals such as PCBs. This has prompted the EPA and many state regulatory agencies to limit the levels of such contaminants in sludges and the amount that can be applied to the land. By following these guidelines—such as applying the sludge at predetermined rates and using "clean" sludges—communities should be able to recycle municipal sludge on land safely and effectively.

Wastes Upon the Waters

Managed aquatic systems are extremely attractive alternatives to conventional methods of treating wastewater because they can clean the effluent to about the same level but often can be considerably cheaper. Managers of relatively small treatment systems, especially those handling less than 1 million gallons per day, commonly report savings of 35 to 75 percent in construction, operation and maintenance, and energy costs. Although aquatic systems can require less space than some land-treatment methods, their use by large cities may still be limited by the cost or availability of land.

Full-scale aquatic treatment systems, as well as numerous research and development projects, are operating or under construction in at least 15 states as well as in several foreign countries. These include natural and constructed wetlands; treatment ponds; systems using floating aquatic plants grown in ponds, or ditches; and aquaculture operations involving a variety of freshwater or marine organisms, often in combination with other treatment processes. Aquatic systems may employ a number of physical, chemical, and biological mechanisms to clean the wastewater, ranging from sedimentation and filtration to uptake by plants and breakdown by bacteria.

Some of the wetlands being used or investigated include cypress swamps, bogs and other peatlands, "washes" in the West that fill with water after heavy rains, and both freshwater and salt marshes. Wetlands slow the movement of surface water passing through them, which promotes deposition of suspended particles. The wetland soil, plants, and associated microorganisms assist in the cleaning. Researchers at the University of Florida and the University of Michigan, sponsored by the National Science Foundation, have provided a good scientific basis for wetland treatment in a few types of wetlands, but additional large-scale systems representing other major wetland types need to be installed in different geographical regions. Monitoring them under various conditions will provide "real world" operating information and data needed for developing reliable design criteria. Not all wetlands are good candidates for wastewater treatment—some are too valuable in their undisturbed condition, some are too sensitive to change, and some do not provide much treatment. The EPA is currently evaluating several kinds of wetlands in the Midwest and the Southeast to determine their suitability.

"Artificial" wetlands are less restricted by user conflicts and potential environmental concerns than natural wetlands. They can be constructed almost anywhere—including on lands with limited alternative uses—and they offer greater flexibility in design and operation that can lead to superior treatment and reliability. They can be built in natural settings or they may entail extensive earthmoving, constructing impermeable barriers, or building containers such as tanks or trenches. Wetland vegetation is often established on an artificial substrate such as gravel or peat. Cattails and reeds appear to be ideal plants—they are hardy and widespread, and they propagate easily and grow quickly. In Ontario, for example, an experimental cattail marsh built on heavy clay soils provides efficient year-round treatment. There is only a slight decrease in performance during the winter, when ice forms on the marsh surface but wastewater continues to flow underneath.

Shallow ponds, usually less than two meters deep, can economically treat raw wastewater or remove additional contaminants from partially treated sewage. Such "stabilization ponds" are already widely used at many treatment plants. Bacteria play the major role by decomposing the organic matter in the wastes, and algae provide oxygen for bacterial respiration. Some pond systems are aerated mechanically to allow greater loadings of wastewater than could otherwise be handled.

The water hyacinth, a fast-growing, free-floating freshwater plant that is very efficient in removing nutrients and other materials, is the centerpiece in another aquatic system. About 15 acres of hyacinths, grown in ponds under controlled conditions, can treat 1 million gallons of wastewater to high levels per day. The plants take up nutrients and other chemicals as they grow, and their roots foster the growth of bacteria and higher organisms that assist in treatment. And by creating a blanket of vegetation that reduces wind and wave action on the water, they reduce unwanted growth of algae and help suspended solids settle to the bottom more quickly. Harvesting the hyacinths may be required to keep the system performing properly; 20 to 40 tons of plant material (dry weight) can be harvested per acre after about three months growth. The hyacinths can be digested to produce methane fuel or processed to produce organic soil conditioner or animal feed, but such recycling systems are not yet economical.

The use of water hyacinths was pioneered by scientists at NASA's laboratory in Bay St. Louis, Miss., where the plants have been cleaning domestic and chemical wastewaters since 1975. Systems are also being used or tested in other Southern areas, especially Florida, Texas, and California. For example, Walt Disney World near Orlando, Fla., has installed hyacinth ponds, and production of energy and soil conditioner from harvested plants is being evaluated. And San Diego is building a prototype system that will treat 1 million gallons per day, which will be used to study the potential of hyacinths for large-scale renovation of wastewater. Although hyacinths have proven effective in many locations, their use in colder climates and for treating very strong wastes is limited. The NASA researchers and other groups are now developing more versatile hybrid systems using other aquatic plants such as rushes, cattails, and reeds.

Aquaculture systems that both treat wastes and produce valuable aquatic plants and animals have potential but are farthest from widespread use. In one particularly ambitious project, scientists at Woods Hole Oceanographic Institute tested a marine "polyculture" system that used municipal wastewater. They grew marine algae in a mixture of seawater and sewage effluent, and then fed the algae to shellfish, including oysters, clams, scallops, and mussels. The algae removed nutrients from the wastewater and the shellfish removed the algae. Lobsters and fish such as flounder were then fed the wastes produced by the shellfish, and commercially valuable seaweed provided the final "polishing" of the effluent. The cost-effectiveness of the total system is questionable, but it does appear that the seaweed unit by itself may prove attractive economically.

In other projects, a variety of fish species have been grown in wastewater stabilization ponds. In Arkansas, for example, buffalofish, channel catfish, and several species of Chinese carp were raised in the last four stabilization ponds of a six-pond series in which municipal wastewater flowed from one to another. The fish got no other food. More than 3,000 pounds of fish per acre were harvested after eight months, and the quality of the water discharged from the system was improved. Another possibility is to use the cooling water discharged from power plants and industrial boilers, combined with various agricultural and industrial wastes, to support a commercial aquaculture system. Public utilities in at least ten states are exploring this prospect. However, it appears that aquaculture systems cannot be optimized for both food production and waste treatment in the same unit; systems involving higher forms of animals seem less efficient at treating wastewater and are more difficult to manage. But in some cases it should be possible to combine waste treatment with aquaculture systems to help decrease net costs.

What's Needed for Success?

Several problems stand in the way of widespread acceptance of natural treatment systems. Many natural areas have traditionally served as convenient sites for disposing of wastes, leading to serious environmental problems. Thus, many people automatically oppose integrating natural systems and waste-treatment projects. Also, adjoining landowners, government officials, and special-interest groups often express concern about potential odors, aesthetic problems, noise, and property values. And people often differ widely in their views about land use—such as whether to allow multiple use of public lands or how to balance environmental protection and development. Education in the form of public meetings and information campaigns is the way that many successful programs have approached community relations. Letting people know and see what to expect—

the disadvantages as well as the advantages—helps gain public acceptance.

Even more important, researchers are still uncertain about the eventual fate and long-term impact of some contaminants in wastewater and sludge. The possibility that heavy metals, toxic organic chemicals, or disease-causing organisms may become concentrated in food chains, flow into local streams, or leach into groundwater supplies cannot be ignored. Nor can the potential for disease outbreaks and worker contamination caused by poor management or simple miscalculation—issues often raised when natural treatment systems are proposed. Research continues in these areas but needs more emphasis. However, natural treatment systems should not be singled out as having ecological problems; conventional treatment facilities release the same materials, merely to different ecosystems. In assessing natural treatment, environmental effects should be compared to those of available alternatives and not to "zero risk."

Good project design and management is the key. And appropriate siting and thorough monitoring will go far toward assuring both scientific and public confidence in these systems. Most, if not all, environmental problems can be avoided or mitigated by using proper management controls. For example, sludges can be treated to stabilize odor-causing organic materials and to reduce pathogens and toxic chemicals to acceptable levels. Wastewater and sludge can also be applied according to crop needs, weather conditions, and waste-production rates. And pretreating industrial wastes before they are put into the sewer system should greatly reduce contaminant concentrations in the effluent and sludge produced at many municipal treatment plants.

Appropriate regulations and guidelines are also essential. These should allow a measure of flexibility that reflects how a system is used. Designers and managers of systems devoted primarily to sewage treatment—where the public has few opportunities to come into direct contact with waste—should have greater leeway in choosing application rates, pretreatment, and other procedures to hold down costs. For example, California's Department of Health has long allowed different uses of wastewater that has received different levels of treatment and disinfection. The degree of treatment required is tailored to the specific use: for example, whether it's for use on cropland, golf courses, or highway medians. Many states have also adopted regulations or guidelines for the controlled use of sludge in agriculture, and some have guidelines for forestry and land reclamation.

The purpose of a natural treatment system must be clarified early in the planning stage. Projects can be designed and operated solely for waste treatment and disposal or to achieve multiple benefits, including crop production, water conservation, and the like. The choice will determine how to balance technology and operations, costs and benefits. For example, if obtaining multiple benefits is the goal, project costs may be higher because more land and equipment is needed, application rates may be lower, and pretreatment may be more thorough. But under the right conditions, the value of marketed products or other benefits can offset such additional costs. On the other hand, if waste treatment is the only goal, simplified natural systems that cost less but don't provide other benefits may be more appropriate.

There are also a variety of more practical problems. Building all the components of a system—transmission lines, dikes, weirs, impoundments, storage facilities, access routes, and monitoring stations—without seriously disrupting natural areas can be difficult and expensive. This is especially true in wetlands and forests. And many sanitary engineers and public officials simply prefer dealing with established technologies for treating wastes. Despite recent government efforts to encourage use of innovative technologies, such as the EPA's construction grants program, few consulting engineers and equipment manufacturers have expressed interest. This is not entirely surprising. Natural systems require less equipment and feature simple engineering designs, so profit opportunities, at least in the short term, are not enormous. Natural treatment systems will be accepted slowly unless government agencies aggressively promote their development and use.

Sewage disposal is a complex task: done improperly, it can adversely affect the air, land, water, and ultimately, people. We must be careful not to simply shift the problem from one environmental medium to another. But properly managed natural ecosystems, although no panacea, do offer an ecologically acceptable way to deal with pressing water-pollution problems at reasonable cost.

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CHEMICAL RIVERS

Cleaner today— but clean enough?

Despite years of debate, arguments and attempts to agree on how best to clean up the country's waterways, the Environmental Protection Agency and the chemical industry are still bickering about how to define Best Available Technology (BAT). Meanwhile, the clock is ticking on all parties.

By 1984 all industries are supposed to use BAT to remove toxic pollutants from effluent discharged into surface waters, according to the 1977 Clean Water Act. So far, however, EPA, whose job it is to define BAT for individual industries, has set standards only for the forest products industry.

The lack of a current standard puts the chemical industry between a rock and a hard place. So the industry is acting as if Best Practicable Technology (BPT)—those methods industry and EPA alike considered adequate to meet 1972 deadlines for a first pass at cleaning up—will be acceptable under the 1984 rules. "If EPA defines current treatment technology as BAT, then everything will be okay," says Geraldine Cox, vice-president of the Chemical Manufacturers Assn. If, however, EPA decides to require a new generation of treatment technology to meet BAT standards by 1984, she warns, "the industry will not have enough time to build the necessary facilities."

The entire Clean Water Act is up for reauthorization this year, and industry executives had anticipated that Capitol Hill debates on the legislation would be an excellent forum for their case. But Congress has not addressed the issue, and time has run out.

Rivers' fate. The eventual quality of the nation's rivers may depend on the resolution of the treatment controversy. Prior to the passage of the 1972 amendments to the Federal Water Pollution Control Act, the Clean Water Act's forerunner, many rivers in the U.S. were little more than open sewers. Today, pollution is rarely as viscerally offensive, but it is still a problem. Virginia's James River and New York's Hudson River are two prime examples.

The Virginia Water Control Board has been monitoring water quality in the James River since 1976, when the pesticide kepone was discovered there. The river is open to recreational uses, but fish species with kepone concentrations above 0.3 part per million remain banned for commercial fishing.

Virginia may reconsider and allow fishing in areas where kepone in fish tissues is somewhat higher than 0.3 ppm. Nevertheless, state officials say that fairly high levels of the pesticide in river sediment will lead the state to continue to track health effects.

The Hudson River, meanwhile, is plagued with polychlorinated biphenyls (PCBs). General Electric's capacitor-manufacturing facilities at Hudson Falls and Fort Edward had been discharging PCBs for more than 25 years. Even though the dumping was stopped several years ago, state officials estimate that 600,000 lb of the chemical, which is toxic to aquatic life and accumulates throughout the aquatic food chain, lies in the river-bottom sediment.

"Discharge from the industry has been reduced to less than one gram of PCB per day," says a state report. "However, it has been estimated that natural flushing of sediments would take 50 years to disperse the PCBs from the bed of the Upper Hudson." Even then, the report says, "much of the contamination would end up in the lower estuary and remain there indefinitely."

How necessary. New York State is seeking financial assistance for a $30 million dredging project to remove sediment from PCB "hot spots"—over 50 ppm—in the Upper Hudson. But state environmental officials have yet to decide whether it is necessary to remove low, but chronic, levels of PCBs from river water used by municipalities.

By and large, such severe abuse of surface waters has been eliminated.

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And chemical companies would like to see their work as done. "The chemical industry has spent about $10 billion on water treatment," Cox says, "and has taken out 90% of toxic materials." The toxics left in the rivers, she says, represent concentrations of previous toxic discharges in sediments. Now the main sources of river pollution, Cox says, are municipal sewers and non-point, or general, runoff from urban, mining or agricultural areas.

State officials agree. For example, Walter O'Shinski, an engineer with Pennsylvania's Environmental Resources Dept., says that about 75% of water-quality violations in the southwestern part of the state stem from non-point sources, particularly acid drainage from abandoned mines. And in Illinois, an ordinance passed in 1969 by the Chicago area's Metropolitan Sanitary District (MSD) all but ended industrial discharge into the Chicago River.

With no new standards for cleaning waterways, industry is ad-libbing and hoping

In fact, Cecil Lue-Hing, MSD's director of research and development, says that industry violations of water-quality rules in the Chicago area have fallen off steadily since 1978. He notes that the state no longer worries about the infrequent spills of toxic substances such as chloride, arsenic, lead or mercury, and that stiffer pollution regulations are unnecessary.

Waters in the Chicago area are still polluted, however, as are parts of the Illinois and Des Plaines rivers, a section of the Sangamon downstream of Decatur, and sections of several other downstate rivers. Most violations of water-quality standards, according to the Illinois EPA, are caused by naturally occurring iron and by high levels of fecal coliform bacteria, which probably stem from untreated sewage.

Optimism. Chicago officials are optimistic that the problem of sewage runoff in their area will be curtailed by a deep tunnel now under construction. It will hold sewer overflow—a major problem during rainstorms—for later diversion to the city's treatment plants.

Elsewhere in Illinois, farmers, pressed by the state, have started a voluntary program to manage agricultural pollution. Moreover, says Kenneth Rogers, supervisor of the Water Monitoring Div. of the state's environmental agency, ambient water quality should improve in the next few years as various municipal projects for waste-water treatment are completed.

Michigan waterways are in sorrier shape. Attesting to this is a total ban on fishing in eight rivers, including the Tittabawassee—which runs through Midland. Mich., the home of Dow Chemical—Saginaw, Pine, Chippewa, Raisin, Kalamazoo, Portage Creek, and Shiawassee.

PCBs in fish. In most cases, fish bans resulted from PCB pollution. But Michigan also found dioxins in concentrations from 2 to 100 parts per trillion in Saginaw Bay and in the Tittabawassee River, downstream from Dow Chemical. The state is still looking for the source of the dioxins, says John Shauver, an environmental official with the state's Natural Resources Dept. Shauver notes that Dow has not yet been exonerated. It is in Midland that the company manufactures herbicides 2,4,5-T and 2,4-D, and dioxins are a by-product of the process. Dow denies that its operations are causing the pollution.

Michigan has also placed "Do not eat certain fish" bans on five other rivers: catfish from the Cass River, carp from the Grand, bullhead and trout from the Hersey, carp from the St. Joseph, and muskellunge from the Detroit and St. Clair. In most cases, says Shauver, the fish are contaminated with PCBs. But the muskellunge also are contaminated with mercury, and the bullhead and trout with polynuclear aromatic hydrocarbons.

Resistance. Chemical companies are growing more resistant to what they see as arbitrary fishing bans in some states. Many companies even insist that the problem is no longer one of toxics in the river, but of analytic ability to spot them. In some cases, they say, errors in detection indicate pollution problems in rivers that have acceptable water quality. And they complain that in many areas the local press has used scare tactics to convince the public that relatively harmless levels of pollution pose health hazards.

The push is on to generate sufficient information on the current state of U.S. rivers, and to set priorities for further cleanup in areas for which data are available. The following look at some of the country's most critical rivers provides a better picture of how far the cleanup effort has come.

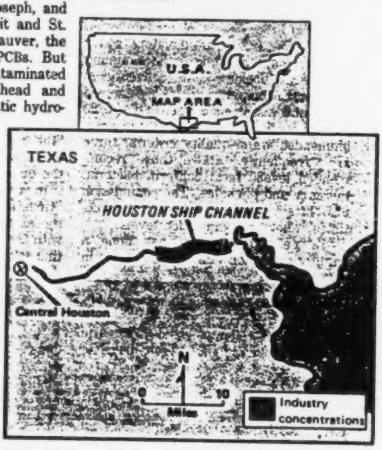
THE SHIP CHANNEL

A 'water wasteland' 20 years ago is now brimming with fish

In 1971, one privately funded study referred to the Houston Ship Channel as a "water wasteland. . .the most poisoned and, potentially, the most explosive body of water in the United States." Wayne J. Crouch, biology group chief of the Texas Water Resources Dept., recalls that "in the late 1960s and early 1970s, after a day of taking samples my hands were all red and chapped."

Since then the channel has undergone a metamorphosis. "The numbers and kinds of fish [in the channel] have really increased; they're piling up like crazy," says Crouch. "Fish are a good indicator of water quality—if the water is bad, they either leave, or it kills them."

Home of petrochemicals. The 50-mi-long channel, dredged in 1914 to provide Houston with a port, is now the third-largest seaport in the U.S. It is also home to the world's largest concentration of petrochemical plants, most of which use the waterway as their only ocean access.



Some 190 industrial and 164 municipal points discharge into the channel. By the late 1960s, the quality of the channel's water had deteriorated far enough for biochemical oxygen demand (BOD) to be estimated at 460,000 lb/day and for dissolved oxygen to be close to zero. Of total pollution loading, according to the Water Resources Dept., industry was responsible for 69% and municipalities for 31%.

Because of rigid application and enforcement of water-quality statutes, the tables are now turned. Dissolved oxygen ranges from 1.5 to 4.0 mg/l and BOD has plummeted to 68,000 lb/day. Notably, industry contributes only 27% of total pollution loading on the channel, with municipal sewage contributing the rest.

"The Houston Ship Channel is clean," says Robert W. Maser, manager of staff services at Ethyl's plant in Pasadena, Tex. Maser, who took part in the company's $10 million cleanup at the plant, also has lived adjacent to the channel for the past 6 years and nearby for 25 years. Until 1969-1970, he says, there was no visible life upstream of the San Jacinto Monument, about halfway to Galveston Bay. Today, he says, "fish and birds are up here all the time. People eat the crabs."

OHIO RIVER

Though industry's efforts are laudable, serious problems remain

The Ohio River Valley Water Sanitation Committee (ORSANCO) monitors water quality along the Ohio at 33 sampling stations. It looks for 29 conventional pollutants, temperature, pH, dissolved solids and dissolved oxygen. Of the 20 substances for which ORSANCO has recommended water-quality criteria, three are "frequently" above those recommended levels: fecal coliform bacteria, mercury and phenolics. The commission also lists cyanide and lead as "sometimes" above recommended levels.

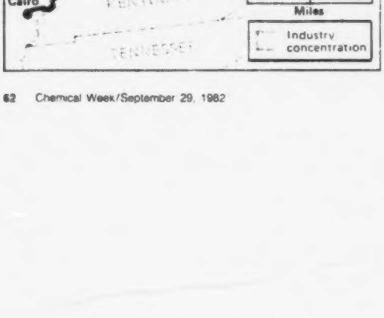
"In general, industry has done a slightly better job than municipalities in cleaning up," says Perry K. Bryant, environmental coordinator for the West Virginia Citizens Actions Group, an environmental organization. "But there are still some serious problems along the Ohio River," he says, citing "a persistent problem with phenolics," the source of which has not been found.

ORSANCO initiated an organics-detection system in 1978 at 11 sites along the river. Initially, the purpose was to detect unreported spills, but the detection system has turned up other disturbing facts. For example, it has shown low but persistent levels of volatile halogenated organic chemicals at every sampling site. During the 1980-1981 detection period, ORSANCO took 4,972 samples and made 15,648 detections of organic chemicals. Eighty-five percent represented concentrations of one microgram/liter or less. Only 0.5% were in concentrations of 10 mcg/l or more. Chloroform was the most common, represented in 72% of the samples, followed by tetrachloroethylene, which was found in 49% of all samples.

Displeased. Many ORSANCO officials do not look lightly on the presence of these organic chemicals. They expressed their concern in a "Draft Work Plan for Water Quality Investigations," prepared by the commission's chief engineer, Leo Weaver. In a July 16 memorandum to the commission's technical advisory committee, Weaver conceded that organic chemicals were well below recommended criteria. "However," he wrote, "the levels detected indicate considerable amounts of these chemicals, given the quantity of flow in the river."

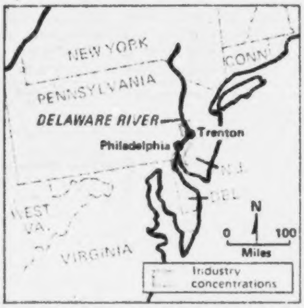
In the report itself, Weaver says, "Generally, sources are unknown, as is the extent of control programs to deal with the compounds." He recommended that ORSANCO undertake:

- A major statistical analysis of the vast amount of data with respect to specific volatile organic compounds to deduce trends and identify sources.
- A sampling program to detect organic chemicals in sediments as well as in water.
- An assessment of acute and long-term health effects of the identified compounds.
- A control program to minimize the discharge of trace organics in areas where significant problems are identified.



DELAWARE RIVER

What ran black in the 1940s is now largely in compliance



So putrid was the Delaware River during the 1940s that the stench often nauseated dock workers and seamen. Over 200 industries within the city of Philadelphia alone discharged solid and semisolid waste into the river. "During warm weather," recall writers of a recent report by the Delaware River Basin Committee, "dissolved oxygen levels were zero for wide reaches of the river, and it would run black and emit hydrogen sulfide."

Forty years of pollution abatement and $1.5 billion laid out by industry, cities and the federal government have brought the Delaware River largely into compliance with current standards. Industry may be asked to do even more, however, if EPA issues effluent guidelines for the chemical industry as promised later this year.

Striking distance. Chemical executives do not seem upset about the potential of more stringent requirements. Rohm and Haas, which manufactures pesticides at several sites along the Delaware River, has reviewed EPA's proposed pesticide-effluent guidelines. "We're within striking distance" of complying with them, according to Duane G. Clarke, the company's technical associate for environmental affairs.

The company is "talking in terms of fractions of pounds of pesticides for each thousand pounds of discharge," Clarke notes. "Sure, it may cost a fair amount of money, but we think some of [the rules] are necessary."

So far, Rohm and Haas has spent $8.7 million on water-treatment equipment at its four facilities on the Delaware. Charges for operating and maintenance, plus fees to local municipal-treatment works, totaled $4.5 million last year. Says Clarke: "There have been significant and visible changes in the river. I've even heard that old wooden piers in Philadelphia are rotting faster now that there is more oxygen in the water."

Indeed, in the nontidal portion of the Delaware, north of Trenton, N. J., pollution that once came from the heavily industrial areas embracing Port Jervis, N. Y. and the Allentown-Bethlehem-Easton, Pa., region has been cleaned up. In the tidal portion below Trenton, pollution has been halved since 1958.

More swimmable. Overall, says the Delaware River Basin Commission, 81% of the river is meeting federal "swimmable" standards and 89% of the river meets federal "fishable" standards, goals set forth in the Clean Water Act for 1983. By 1983, the commission expects 85% of the river to be swimmable.

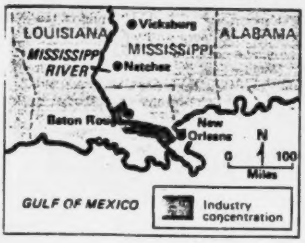
But the remaining 15%—in the middle of the Delaware River estuary in the section running near Philadelphia—is still in trouble. "The middle portion of the Delaware River," says J. Paul Jones, an environmental engineer with the state's Natural Resources Dept., "will certainly require much more time to meet the water quality goals set for 1983."

LOWER MISSISSIPPI

Companies resent a new batch of water-control regulations

From the Arkansas state line to its outlet into the Gulf of Mexico, the Mississippi River is classified by Louisiana as either "effluent-limited" or "water-quality limited," the more restrictive classification. In the most heavily industrialized area between Baton Rouge and New Orleans, the Mississippi is an unmistakable "WQL."

Along this river, which drains about 40% of the continental U. S., fecal coliform bacteria is the main culprit, a clear sign of municipal sewage problems. Even so, industry will likely have to tighten effluent controls because the state is rewriting its control laws for air and water pollution.



The new regulations, according to Frank Thomas, an environmental control specialist with Louisiana's Natural Resources Dept., "will be much tougher and more specific than they have ever been." Among other things, he says, they will address toxic substances for the first time.

The new approach, Thomas says, will be to take "designated use" as the key. "And when you are talking about the Mississippi River," he adds, "you are talking about the source of drinking water for some 1.4 million people."

Not surprisingly, industry considers this new attack misguided. James Cooper, Allied Corp.'s regional manager of pollution control, says that the daily press has overstated water quality problems, and the resulting public pressure has elicited reactions from regulatory agencies. Says Cooper: "We have inspectors in our plant on a monthly basis monitoring our discharges. We have nothing to hide, but we realize that [the regulators] are just reacting to public pressure to do something."

Overall reduction. Cooper claims that all companies along the Lower Mississippi are reducing effluent waste. Allied alone, he says, has spent well over $10 million at its complex in Geismar, La., to reduce emissions of ammonia, phosphates, and suspended solids and to control the pH levels of effluents.

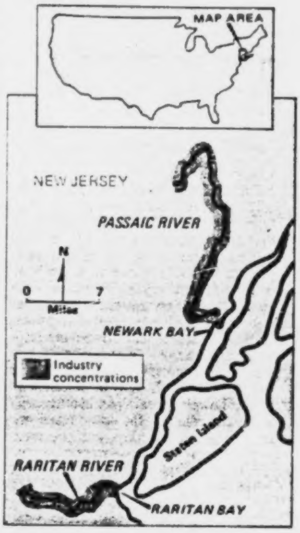
Companies with operations on nearby rivers also feel unfairly maligned. Du Pont has a complex in Beaumont, Tex., bordering on the Neches River, west of the Mississippi. According to Robert B. Bonczek, Du Pont's environmental director, the Beaumont facility has BPT in operation, yet the company fears that "someone might want to require the company to add more technology on top of what we have now."

In order to have ammunition to fight such a rule, Du Pont measured water quality this summer for the 129 pollutants deemed top priority by EPA. After sampling water downstream, upstream, and at the plant's outfall, says Bonczek, the company found a handful of priority pollutants "in the low parts-per-billion range." He concludes that "the plant has a neglible impact on water quality. There is no toxics problem."

Indeed, Bonczek says, "most rivers have no toxics problem. What we do have is a problem in assessing the data provided by laboratory equipment."

RARITAN, PASSAIC

No significant improvement or decline over the past five years



"The quality of surface waters in the state has shown no significant improvement or decline over the last four to five years," according to the 1982 New Jersey State Water Quality Report. "The conventional data collected indicate that there is widespread fecal coliform contamination and excessive nutrients—total phosphorous—in the surface waters of the state." Overall, the report says, 45% of the waters sampled exceeded phosphorous standards, 4% exceeded dissolved oxygen standards, 3% exceeded un-ionized ammonia standards, and 2% exceeded standards for total dissolved solids.

As for toxics, including volatile organics, pesticides, PCBs and heavy metals, "their presence in the water column, sediments and fish tissue also seem to be fairly widespread at very low concentrations," the report says. "Volatile organics were found heaviest in water adjacent to or flowing through industrialized urban/suburban centers."

The lower portions of the Raritan and Passaic run through some of the Northeast's densest industrial areas. A recent state report lists 81 major dischargers on the Lower Raritan, including Du Pont, GAF and Rhone Poulenc. The report on the Lower Passaic reads nearly identically: 87 major dischargers, including such giants as Hoffmann La Roche and Mobay.

The 1982 report contains a watershed ranking system, the first of its kind, based on concentrations of dissolved oxygen, phosphorus, un-ionized ammonia and total dissolved solids. It attempts to set priorities according to the degree of impairment and the type and extent of water use. Two of the most seriously impaired bodies of water, by survey ranking, are the Lower Raritan River and the Lower Passaic River.

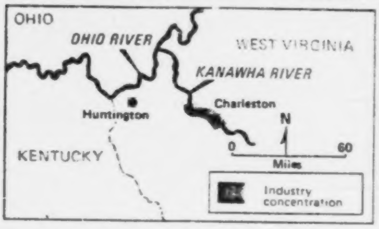
Controlling runoff. The water quality of the Lower Raritan, judged on four ranking parameters and on the presence of toxics, is moderate to poor, according to the report. It recommends the control of storm-water runoff, an upgrading of all waste-water treatment facilities to a secondary treatment level, and consideration of "the feasibility of halting leachate migration from one or more of the landfills in the watershed."

The Lower Passaic has similar problems, according to the state, which rated the water quality as "generally poor." The report recommends the control of municipal discharges, elimination of combined sewer overflows, and control of non-point pollution sources for urban areas. "However," the report cautions, "for these above recommendations to have any effect, it is imperative to enact remedial measures to improve both the upstream segment and Newark Bay waters."

KANAWHA RIVER

Where fishermen are warned to abstain from their catch

At least one man's critique of the Kanawha is succinct: "It's cleaner than it used to be, but that's only because it was practically dead 10 years ago." So says Perry K. Bryant, environmental coordinator for the West Virginia Citizens Actions Group.



Bryant goes further, insisting that "we still have an awful long way to go" to rejuvenate the river. For their part, chemical companies insist that the onus is on municipal sources to do the remaining cleanup.

Residents in the area seem to agree with Bryant's assessment. In 1980, Du Pont, Union Carbide, Monsanto, Diamond Shamrock, FMC, and other chemical companies in the Kanawha Valley shelved a planned campaign to polish their image when a survey showed that few people held them responsible for the pollution of their river.

A lot of money. FMC, for one, has spent $12 million on a system to abate water pollution at its plant in South Charleston. Remarks one FMC executive: "It is absolutely unquestionable that the [Kanawha] river is cleaner today than it was when the first laws were passed."

People are now fishing in and along the Kanawha River. But Bryant, who looks with a jaundiced eye on what may come up on their lines, says that he would "strongly urge people not to eat what they catch."

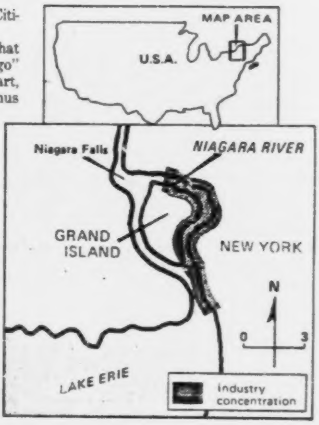
NIAGARA RIVER

Manmade chemicals move from here to ecosystems elsewhere

The 36-mi-long river dividing the U.S. and Canada in western New York State carries the waste of 20 major industrial and 7 major municipal dischargers. As a result, according to a report prepared by New York State, "numerous manmade chemicals have been observed in the Niagara River and some of these have shown up in the Lake Ontario ecosystem."

Some of these organic chemicals can undoubtedly be traced to nearby dumpsites like the infamous Love Canal. A number of such sites are being studied jointly by New York State and EPA under Superfund.

In a recent analysis of sediments from four sites in the Upper and Lower Niagara, says the report, a number of synthetic organic chemicals were found, including chlorobenzenes, phenols, aliphatic alcohols and mirex. About the Niagara River's water, a Canadian report states that "between 1975 and 1979, weekly sampling at a fixed station adjacent to Niagara-on-the-Lake show that, apart from an increasing trend in concentrations of iron, no upward trends have occurred in the concentrations of metals."



Knowledge gaps. But New York's report indicates that "there are gaps in our knowledge of chemical levels and distributions in the Niagara River that must be filled to facilitate future cleanup and pollutant control." The report criticizes the monitoring that was done for being "widely spaced in the river and not always in the near-shore area," where the plant outfalls are located. It also says that the monitoring has turned up "little information on the loading of manmade chemicals to the river from Lake Erie and the Upper Great Lakes."

But the chemicals that do find their way into the Niagara River very likely will end up in Lake Superior. Once there, these chemicals, which include mirex and dioxin, bio-accumulate in fish flesh and may pose a hazard to humans. The report says that this "is undoubtedly occurring today with numerous other manmade chemicals."

Nonetheless, chemical companies in the area say that the river does not have appreciable problems with toxins. Robert R. Benczek, Du Pont's environmental director, says that his company has spent a "fair amount on control technology" for its plant on the Niagara, and he maintains that existing levels of treatment are enough to guarantee acceptable water quality. ☐

Chemical water

Winners and losers in the coming crisis

Ever since national concerns about water quality surfaced well over a decade ago, the attention of chemical industry management has been riveted on the contamination of water resources and the enormous task and cost of meeting increasingly stringent standards of purity set by federal, state and local regulators. If an attitude about the potential availability of water did exist in the chemical industry, says Ronald A. Lang, executive director of the Synthetic Organic Chemical Manufacturers Assn. (SOCMA), it bordered on incredulity. The likely comment to any questions about planning for possible shortages, Lang says, would be, "I've got 35 fires burning and you're telling me that pile of rubbish in the corner is gonna start flaming 15 years from now? Come on."

Federal hydrologists do not share chemical executives' rosy view of water supplies

Even now, the vastness and the complexity of national water issues, as well as other urgent and more tractable issues, have resulted so far in only a limited involvement by chemical companies with the water-availability issue. But a few, reports Lang, have heard the distant clap of thunder and are scurrying for shelter:

- The Emerging Issues Committee of SOCMA has added water supply to its list of concerns. Although some discussions about water supply have taken place, Lang notes, the committee has not grappled with the issue in any substantive manner.
- Three chemical process industry firms—FMC, SmithKline Beckman and Zimpro—were among the six original industrial sponsors of the National Water Alliance that was founded late last year by a bipartisan group of senators and congressmen. NWA's purpose is to develop and promote a national water policy independent of any that may be developed by the Administration. Among other things, it would gauge the adequacy of governmental water policies.
- Water management is increasingly being recognized as a discrete management function, not only for water quality enhancement but also for its cost-saving potential, says Sydney Costa, manager for technology at Calgon, a water-treatment chemical firm based in Pittsburgh. Du Pont, for example, has a group of water specialists at its Louviers engineering center in Wilmington. These specialists function as consultants for supply, quality and other water-associated matters for the firm. And outside of the chemical industry, companies such as Xerox and Hershey have institutionalized water management.

Perhaps the most compelling reason for more concern about water availability by the chemical industry is the sheer size of its requirements. Of the 450 billion gal/day (bgd) of fresh and saline water withdrawn in 1980 for all off-stream purposes—irrigation, sanitary use, livestock, etc.—industrial use was by far the greatest. According to recent estimates by the U.S. Geological Survey (USGS), withdrawals by thermoelectric power plants, 210 bgd, and other industry, 45 bgd, represented 55% of the total consumption. Irrigation, at 150 bgd, was the second largest use.

And the chemical process industries in general and chemical and allied products industry in particular are the biggest users among all manufacturers. In 1978, when the last Census of Manufactures' water survey was performed, the CPI took 87.5% of all the water used in manufacturing. Chemical companies were by far the biggest users, accounting for one-third of the total for all manufacturing companies (*tables, p. 36*).

Moreover, available data indicate that water consumption in the chemical industry has been rising. Intake in 1978 was 61% higher than in 1954. About 90% of the chemical industry's withdrawal, however, is returned to streamflow.

The water users. Seven of the nation's 21 water-resource regions account for nearly 90% of the industry's withdrawals (*map, p. 35*): Texas Gulf (19.7%); Lower Mississippi (18.5%); Mid-Atlantic (11%); South Atlantic (11%); Great Lakes (11%); Ohio (11%); Tennessee (7%).

As water intake has grown in the chemical industry, so has the practice of recirculating the water. Census of Manufactures' figures show that gross water consumption, the amount that would have been used if there were no recirculation, increased 2.7%/year between 1954 and 1978. During the same period, water intake rose only 2.4%/year.

Capital intensive, water projects need long leads. Planning for 2000 starts now

The trend to more reuse of water will have an impact on the rate of withdrawals by the chemical industry in the future, but the magnitude of that impact is hard to forecast. The U.S. Water Resources Council estimated chemical industry withdrawals at 13.5 bgd—4,927 billion gal/year (bgy)—for the hypothetical base year, 1975. USWRC predicted that withdrawals under base meteorological conditions would drop sharply, by 3,000 bgy, to 1,900 bgy by the year 2000. The key, Texas Gulf region, though, is expected to buck the trend through 1985 as withdrawals are projected to more than double, to 544 bgy. By the year 2000, according to USWRC, withdrawals would tail off slightly to 528 bgy. Actual consumption of water—water not returned to streams or wells—will show a marked increase. USWRC projects chemical water consumption of 1.49 bgy by 2000, soaring from the 480 million gal/year estimated nationally for 1975.

Although chemical executives profess confidence that there will be ample water to meet their needs, their rosy view of future water supplies is not shared by federal hydrologists and other qualified students. To be sure, the U.S. as a whole does not face a water shortage—as stated in last month's 245-page *National Water Summary 1983* assessment by USGS. The renewable supply of water in streams and aquifers is 1,400 bgd, some three times the present rate of withdrawal and 14 times higher than present national consumption. But the actual availability of water from developed resources through storage and distribution systems is an entirely different matter. In fact, when the practicalities are considered, only 675 bgd of fresh water can be considered available in 95 out of every 100 years in the 48 conterminous states. If the growth rate of water continues at the same 1.1%/year rate as in the 1975-1980 period, total offstream use would reach the 675 bgd threshold in 50 years.

The USWRC found localized surface water supply problems in all of the na-

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The chemical water cycle

Sources of water for chemical plants

By Source	Quantity (billion gal/year)
Public water systems	727
Company systems	3,399
•Surface water	2,251
•Ground water	366
•Tidewater	782
Other	200
By Type	
•Fresh	3,425
•Brackish	182
•Salt	719

Source: Census of Manufactures, 1978.

Where chemical companies discharge water

Discharge	Quantity (billion gal/year)
Treated	
• Public utility sewers	101
•Streams and rivers	604
• Lakes and ponds	108
•Bays and estuaries	129
•Ocean	NA
•Ground (wells, spray, seepage)	18
Untreated	
•Public utility sewers	307
•Streams and rivers	2,384
• Lakes and ponds	127
•Bays and estuaries	94
• Ocean	3
• Ground (wells, spray, seepage)	10
• Other	18

(NA) Not available.
Source: Census of Manufactures, 1978.

How water is used in chemical plants

Use	Quantity (billion gal/year)
Process	754
Cooling and condensing	
• electric power generation	480
• Air conditioning	71
• Other	2,760
Sanitary service	38
Boiler feed	112
Other	81

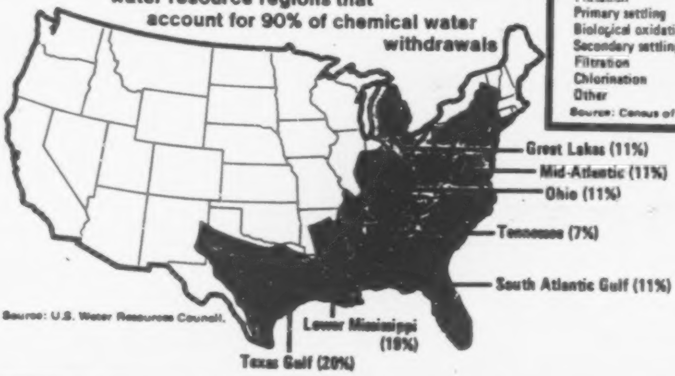
Source: Census of Manufactures, 1978.

How chemical effluents are treated

Treatment	Quantity (billion gal/year)
Surface skimming	216
Neutralization	472
Coagulation	94
Flotation	24
Primary settling	336
Biological oxidation	202
Secondary settling	191
Filtration	34
Chlorination	216
Other	176

Source: Census of Manufactures, 1978.

The top seven water resource regions that account for 90% of chemical water withdrawals



Source: U.S. Water Resources Council.

tion's 21 water-resource regions. And by the year 2000, 17 of the nation's 106 water-resource subregions will have serious shortages of surface water.

Moreover, extensive groundwater "overdrafting"—pumping groundwater out faster than it is naturally replenished—already exists in eight subregions: another 30 subregions experience moderate overdrafting. Chemical companies in the Houston area, reports Exxon environmental coordinator James B. Cox, have already been forced to shift to surface water because of the overdrafting problem.

The USWRC assessment made an attempt to arrive at a highly quantified measure of the adequacy of future water supplies under both normal and dry conditions. In contrast, the new USGS report leans more heavily on average conditions and is, in general, more qualitative. The *National Water Summary 1983* of the USGS shows consumption of water, as a percentage of renewable supply, exceeding 2% in only one of the seven resource areas that account for 90% of the chemical industry's withdrawals. The exception is the Texas Gulf region, where the figure is 25%.

Approaching the availability problem in the Texas Gulf from a different direction, USWRC reaches the same general conclusion—for periods of normal rainfall. It measures depletion by calculating the offstream use as a percentage of total streamflow, and it estimates that at 33% for the base year, 1975. Further, USWRC projects that under conditions of a base scenario, this measure of depletion would be essentially unchanged by the year 2000. For the other big chemical-producing areas, the percentage is much smaller.

Depletion. The USWRC study shows an even less reassuring picture for dry conditions, such as would stem from moderate droughts once every five years. For the Texas Gulf watershed, depletion under those conditions would have been 69% in 1975 and above 63% through the year 2000. Drought-caused boosts in depletion ratios in the other six chemical regions were generally small.

Although the impacts on the chemical industry are limited when only depletion rates are considered, a second measure of water-resource adequacy by the USWRC strongly suggests that big problems will soon confront the nation's water users. This measure, the ratio of total use—instream and offstream—to total streamflow, gauges the potential for conflict in future water use development between instream users, such as fish, fishermen and hydropower plants, and offstream users, such as the chemical industry.

Any value in that index of "future conflict potential" over 100% is considered undesirable. And among the seven key chemical-making territories and under base conditions, only the Texas Gulf and Tennessee areas are at or near the 100% mark for the 1975-2000 period.

Where the water goes

Chemical process industries

Industry segment	Water intake* (billion gal/year)
Chemical and allied products	4,326
Paper and allied products	1,963
Rubber, misc. plastic products	187
Stone, clay and glass products	207
Petroleum and coal products	1,173
Primary metals	3,392
All other manufacturing industries	1,745
Total	12,993

*Establishments reporting intakes of 20 million gal or more a year.

Chemical and allied products

Industry segment	Water intake (billion gal/year)
Industrial inorganic chemicals	965
Plastics and synthetic materials	482
Pharmaceuticals	90
Soaps, cleaners, toiletries	ND
Paints and allied products	ND
Industrial organic chemicals	2,151
Agricultural chemicals	302
Miscellaneous chemicals	189
Total	4,326

(ND) Not disclosed. Source: 1977 Census of Manufactures.

But under dry conditions, the future conflict potential approaches serious dimensions. In years of moderate drought, the index is over 100% in all conterminous water-resource areas. And the index is at its highest, 197%, in the Texas Gulf region. Only slight improvement—to 193%—is projected for the year 2000. In the lower Mississippi region, which embraces Louisiana, the index—86-89% in average years—shoots to 129-134% in drier ones.

Index values over 100% do not necessarily mean that industry or agriculture will go thirsty; indeed, under the USWRC dry scenario, chemical industry water withdrawals do not decline. But high index values do mean that additional demand for offstream water will clash head on with catfishing and other instream uses. Hence, chemical plant expansion in such areas would face severe environmental challenges.

Availability questions aside, the cost of water today "gives most process industry companies plenty of incentive to conserve water," says J. William Haun, an ex-Monsanto chemical engineer who is now vice-president for engineering policy for General Mills, as well as an industry advisor for the Environmental Protection Agency (EPA) and the National Environmental Development Assn. The cost of usable water, highly sensitive to a variety of factors, has risen sharply over the past decade. Houston's Water Administration charges to its industrial customers provide one indication of how sharp that rise has been (*table, p. 38*). The highest-volume users, a category that includes refineries and chemical plants, paid 24¢/1,000 gal in the pre-energy crisis year of 1972. By 1982, the price had gone to $1.29/1,000 gal. Last year, as energy costs receded, the price slipped to $1.14/1,000 gal.

Extremes. Water costs, however, are highly variable. Raw surface water that doesn't need too much treatment before use costs 5-11¢/1,000 gal on the Gulf Coast, says Tom Roche, a site location specialist with Houston-based Pilko Associates. At the other extreme is a $1.60/1,000 gal price that Dow Chemical pays for using water in California.

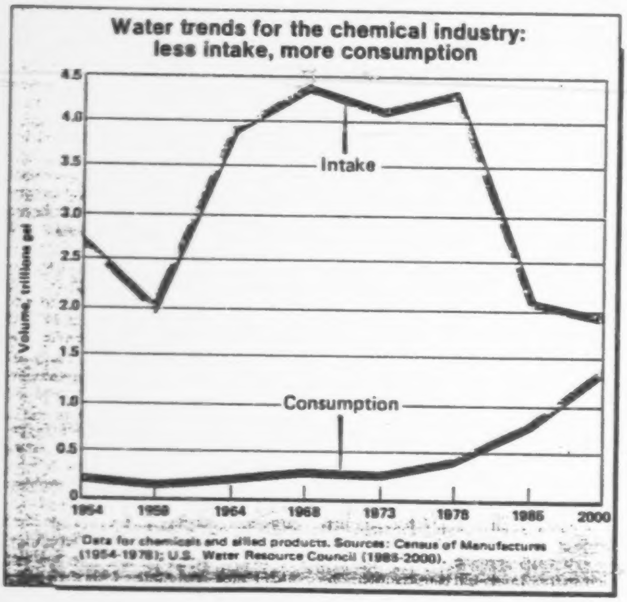
And although the cost of water, exclusive of discharge treatment costs, is not generally considered a major cost item in chemical production, the cost for major chemical complexes is not inexpensive. A 1-billion-lb/year ethylene plant requiring 3,000 gal/minute would spend nearly $500/day for water costing 11¢/1,000 gal. And for the chemical industry as a whole, counting pre-use treatment and post-use cleanup, the present water bill probably exceeds $1 billion/year.

Not surprisingly, big water users are modernizing their company water systems. Chemical companies are, of course, old hands at conserving water. Mobay, example, has cut water consumption 50% over the past decade, reports executive vice-president N. H.

Prater. And Dow, at Varennes, Que., and Dalton, Ga., has gone to the ultimate extreme: zero discharge.

Mead has slashed water consumption at its Chillicothe, Ohio, paper mill to 32 million gal/day from 45 million gal 10 years ago, says John Bowling, manager of environment control. A further reduction, to 25-27 million gal/day, is planned. New machinery has reduced water intake by 67%, to 6,000 gal/ton of waste produced.

On the outlet side, the improvements have reduced solid waste production to 6 tons/day from 20 tons/day, at a saving of $60/ton. Eventually, says Bowling, water cooling will probably give way to air cooling.


Water trends for the chemical industry: less intake, more consumption

Data for chemicals and allied products. Sources: Census of Manufactures (1954-1978); U.S. Water Resource Council (1985-2000).

In fact, a number of Pittsburgh-based chemical process firms also see a brighter future for air cooling, as a widespread switch to this method could go a long way in alleviating future water shortages. However, high ambient air temperatures in some regions—notably the Gulf Coast—could make such a switch costly.

But then many Gulf Coast chemical water managers have few concerns about future water supply. "I foresee no problems [of supply] in the coming years," says S. G. Pappas, manager of environmental and governmental affairs for Monsanto plants in the Texas City-Bayport-Chocolate Bayou area. And Exxon's massive Baytown facility is as close to zero discharge "as it's ever going to get in my lifetime," says Cox. The complex recycles 800-900 million gal of water through the system daily, but needs only 35 million gal/day to make up losses. The firm switched all but 1-2 million gal/day to surface water in 1973 and the remainder in 1980. The wells are now on standby.

Curiously, neither Monsanto's Pappas nor Exxon's Cox regards the past switch from groundwater to surface water because of ground subsidence as an example of a water-supply shortage. The local aquifer "still has an adequate supply," says Cox. Still, Exxon went to the cost and trouble of digging a canal—4.5-miles long, 75-ft wide and 12 ft-deep—to bring water from the San Jacinto River-Lake Houston region to the plant.

Monsanto's Pappas commends the Brazos River Authority with "pretty well allocating" the water. But he also concedes that "there is not much [water] left for major expansions." New grass-roots complexes will probably have to move farther out toward Victoria or Corpus Christi, he adds.

The chemical industry's preoccupation with water quality at the expense of neglecting water availability is understandable. The primacy of water pollution in the industry's environmental concerns, if anything, was strengthened this month by a new EPA study on groundwater strategy that revealed that present estimates of groundwater contamination are way too low, that there is a gross misunderstanding of the problem, and that there is probably significant underreporting by the federal Centers for Disease Control (Atlanta) of groundwater-borne disease. Moreover, hundreds of thousands of petroleum-industry storage tanks are leaking gasoline and other products into the groundwater. As a result, the policy recommendations that EPA has yet to make, says SOCMA's Lang, promise to make groundwater a burning public issue for a decade.

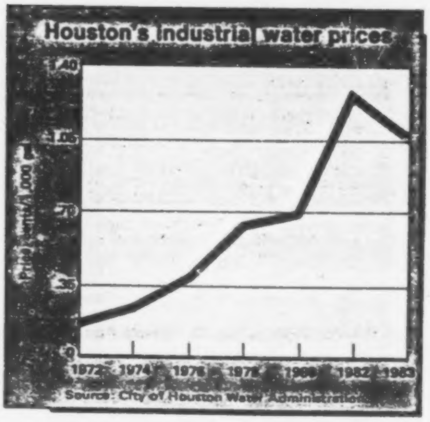
Typical of the entire perception of water issues, the policy will probably give short shrift to the relation of water quality and water supply. Yet the availability of usable water could be reduced to the extent that communities with contaminated groundwater must seek alternative supplies.

'Critical.' Such indirect relationships are typical of many of the 10 "critical" problems concerning water quality and quantity. The 10 were identified in the 1978 USWRC study, the most definitive work on the subject to date.

Fertilizer and pesticide producers, for example, could have a big stake in the withering—in 20-40 years—of the vast Ogalalla aquifer under the High Plains that stretches from Texas to the Dakotas. They could also have a big stake in Ohio, where the problem is erosion and sedimentation, rather than dwindling groundwater.

Most concern about groundwater overdrafting so far has focused on the Ogallala aquifer, a 3-billion-acre-feet deposit of water built up over the ages under a 50-million-acre area that embraces most of Nebraska and parts of Texas, Kansas, Oklahoma, Colorado and New Mexico. The most serious depletion has occurred in the South; the acquifer is still in relatively good shape in most of Nebraska. Overall, 23% will be gone by the year 2020. In Texas, 67% of the aquifer will have disappeared by then.

A variety of water conservation techniques have been suggested to husband groundwater, including dry crop farming and conservation tillage. Dry crop



Source: City of Houston Water Administration

farming relies on rainfall alone for water requirements. Conservation tillage leaves crop residues on the field to bind precious moisture and minimize erosion. And in addition, more efficient irrigation practices can be employed.

The agricultural practices will have a considerable effect on agricultural chemicals. Dry crop farming uses less fertilizer, while conservation tillage increases pesticide, and especially herbicide, use.

Offsets. But counterbalancing trends are at work. For instance, B. A. Stewart, laboratory director, conservation and production, of agricultural research services at the Agriculture Dept.'s Bushland, Tex., research center, says that increasingly over the next 15-40 years "there will be dramatic decreases in irrigated acreage" in Texas, New Mexico and Colorado, where 7 million acres may lose Ogallala water. But that decrease will be offset by a gain in irrigation in Nebraska. Raymond J. Supalla, however, a professor of agricultural economics at the University of Nebraska (Lincoln) puts the gain at 6 million acres, despite Ogallala problems in selected portions of the state. The increase in Nebraska irrigation will involve land now largely used for range.

Estimates by Stewart and Supalla regarding changes in irrigation practices are considerably different from a $6 million 1982 assessment of the Ogallala problem made for the Commerce Dept.'s Economic Development Administration by Camp Dresser & McKee, an Austin, Tex., engineering consulting firm. It showed that irrigated acres would increase to 18 million by 2020, from 14.2 million, while dry crop acreage would climb to 19.6 million acres—from 18.3 million acres in 1977.

Even if there is no net change in the total consumption of fertilizer and herbicides, changes in distribution patterns will occur, says Supalla. And there could be changes in the type of fertilizer required, although "the book on this is still very much out," notes USDA's Stewart. He suspects that as less and less water becomes available, conservation tillage would gain in popularity. As a result, he suspects that liquid urea or deep soil injection of urea pellets would work better than anyhdrous ammonia. At the same time, he cautions that his ideas have not been proved. Conservation tillage would, however, undoubtedly boost the demand for herbicides, as weeds would not be plowed under.

In any event, uncertainties exist. Soybean planting is creeping into eastern Nebraska. And the future cost of energy will have a lot to do with irrigation. Irrigation raises crop-production costs 16-fold, while yields increase only fourfold, says Stewart. And prolonged drought worries Marvin Jensen, a USDA water expert. "What [happens to irrigation] if we get a five-year streak, like in the thirties?"

Seven U.S. water-resource regions account for 90% of chemical industry withdrawals

The use of fertilizers and herbicides may also be ripe for change in states where too much, rather than too little, water is the problem. Ohio affords a case in point. Increased use of "no till" conservation (the most extreme kind) in Ohio could result in a 20% boost in herbicide consumption, says Donald Eckert, an extension agronomist at Ohio State University. In no-till conservation, the soil surface is not broken by any kind of plowing. Hence, weeds proliferate. Conservation tillage is needed because Ohio's copious rainfall creates serious erosion problems as the rainfall runs off. Over 85 million tons of soil is eroded from Ohio land every year.

Nitrogen types. For corn, quantity recommendations for applying fertilizers—nitrogen, phosphorus and potassium—are not altered because of tillage, says Eckert, but the type of nitrogen that's used is. Eckert's service recommends that no-till land be fertilized with anhydrous ammonia or ammonium nitrate rather than with urea or nitrogen solutions, which are attacked by soil enzymes on the surface and broken down to volatile ammonia. Anhydrous ammonia is normally injected too deeply to be affected.

Tillage could cause a drastic drop in nitrogen consumption in Ohio for another reason, however. A big switch to soybeans, from corn, is expected because planting soybeans is easier. And soybeans require only a fraction of the nitrogen demanded by corn.

But while conservation tillage can solve some farm problems, it can create new ones, warns David B. Baker, the director of the Water Quality Laboratory at Heidelberg University (Tiffin, Ohio). Baker stops short of trumpeting an impending crisis related to agriculture's effects on water quality, but he believes that there very well is one in the "lack of information and understanding" of agricultural impacts on water quality.

Conservation tillage, Baker concedes, will greatly reduce erosion and accompanying sediment and phosphorus transport to Lake Erie, where eutrophication was once a long-standing problem. But such tillage, by a complex mechanism involving subsurface tile-pipe drainage, could boost nitrate and pesticide contamination. He claims that nitrate, which cannot be readily removed from drinking water, already exceeds or nearly exceeds permissible levels in 13% of muncipal assays in northwestern Ohio.

Loggerheads. The dimensions of the national water problem span the continent, and not all the issues involve quantity or quality. Fixing the problem may entail hundreds of billions of dollars—and solving a host of political questions. Governments at different levels are at loggerheads: municipalities with states, and states with each other and with the federal government. Compounding the difficulties are questions of water ownership.

In many ways, saline-water intrusion illustrates the complexities of the problem. As groundwater tables drop in coastal states, saline water infiltrates the aquifer system, necessitating relocation of drinking-water wells. Under intense population pressure, some aquifers in Florida have dried up, and stream flows have been decreasing steadily since 1890. Last year, the state's phosphate producers were forced to spend several million dollars to monitor drinking water, which has been found to be contaminated with ethylene dibromide and Temik (aldicarb) in all agricultural areas of the state. Gardinier is considering closing its large East Tampa fertilizer complex because environmentalists have so far successfully balked the company's efforts to build a new gypsum storage stack.

In California, water used for irrigation has become increasingly brackish and harmful to crops. And if drought or excessive withdrawals attenuate streamflow in coastal areas, salt water moves further upstream on major rivers. At Dow's complex at Pittsburg, Calif., the big worry is the salt water that backs up from the bay every time the pumps are started to divert water from the Sacramento River to Los Angeles. A major water project to remedy the problem—the Peripheral Canal—has long been a political football in California because the state's northern residents view the project as a device to steal their water.

On the other side of the country, the Delaware River Basin Commission professes no problems as long as the salt line stays south of the Philadelphia-Camden axis. But augmentation of the Delaware's flow is urged by Nicholas J. Lardieri, a divisional vice-president, environmental resources, for Scott Paper. The company's Chester, Pa., paper mill is almost astride the salt line now.

EPA's coming rulings promise to make groundwater a burning issue for a decade

Statehouses everywhere are increasingly covetous of their water resources. Last November, for example, the Council of Great Lakes Governors agreed to block any attempt by Western states to drain the Great Lakes. In Montana, the state's water rights' court is trying to sort out over 200,000 claims.

Unresolved Indian water claims affect every major river basin embracing western energy fields. The Great Plains Coal Gasification project in North Dakota avoided water-supply litigation only because it negotiated an agreement with three affiliated tribes of the Fort Berthold Reservation, who then elected not to contest the project's water permit. The collapse of synfuel expansion, however, has taken some urgency from the need to resolve water rights.

Beyond the fight over water rights lies a potentially bigger brawl to determine who will pay the bill. The federal government is now spending over $3 billion/year, and there is a backlog of authorized but unfunded projects that total $50 billion, says the National Water Alliance. States, adds NWA, are spending $11 billion/year.

But that's only a drop in the bucket. Federal spending alone to remedy sundry problems, ranging from supply to navigation, could take $243.8 billion (in 1972 dollars) in the 1980-2000 period. An additional $294.2 billion could come from nonfederal sources, mostly states, according to a study published in the September 1983 *Consulting Engineer*.

Already the battle lines are forming. One element of federal water policy is to shift as much load as possible to the states and other beneficiaries of water development. Nationwide, irrigators pay only 19% of the cost of their water projects, says William R. Gianelli, assistant secretary of the Army. And in New York, the state wants Exxon to pay for the fresh Hudson River water that it has been exporting to the Caribbean in dead-heading oil tankers.

Full-cost pricing. Charging more for irrigation water could be a big stimulus to conservation, but if California is any indication, the concept could be a tough sell. The vast Central Valley Project in California, started in 1935 with interest-free funding, now needs to be expanded. At the time of a San Francisco Reserve Bank study in 1982, CVP water was fetching only $5.09/acre-foot, in contrast to an imputed full cost of $23.77/acre-foot. The estimated long-run incremental unit cost of the expansion is $324/acre-foot. No one has yet determined what impact full-cost pricing might have on California produce and its agricultural chemical inputs.

In fact, the question of who pays for water projects is so complex that the Grace Commission's study on trimming federal waste treaded lightly on the issue. Complicating the cost element is the fact that the Reagan Administration dismantled three major federal instruments of water policy development. And the replacement, the Interior Dept.'s Office of Water Policy, has exhibited little urgency in putting together much of a substitute, although a spokesman asserts that the attitude of the office is "positive" and its goal is to leave as much of the management problem to the states as possible.

In the final analysis, the chemical industry and its customers clearly have a stake in the nation's water. In the near future the industry's concerns with the problem may become more evident. Water projects, as SOCMA's Lang points out, are capital-intensive ventures that involve long lead times. In fact, for planning purposes, the year 2000 is already here. □

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Frustrated aspirations for watershed quality management

Edward J. Cleary

The U.S. water pollution control program is bogged down in the many regulations required to enforce uniform, technology-based effluent standards. The disillusionment that has resulted should revive interest in the use of watershed agencies that implement water pollution control on the basis of water quality standards. The experiences of several existing river basin commissions and the U.S. Geological Survey lend support to this premise, especially in view of the advances in monitoring methodology, economic considerations, and adaptability of the watershed institutional framework to the national program.

Starting in the Thirties the inadequacies of water pollution administration by state regulatory agencies prompted advocacy for conducting such activities under the auspices of watershed entities. Political responsiveness to these proposals for the most part has been apathetic and only a few drainage basin coordinating institutions have come into existence. Instead, the quest for reform in expediting pollution abatement moved steadily toward broadened federal jurisdiction.

In 1972 this fixation on federal control culminated in legislation that places primary reliance for improvement on promulgation of arbitrary effluent standards uniformly applied nationwide to all wastewater discharges. Coupled with this unprecedented centralization of authority are massive subsidies for local governments to induce compliance. After 8 years and the authorization of some $28 billion, it has become painfully apparent that the idealistic goals, bureaucratic procedures for their attainment, and unrealistic timetables mandated by this legislation have put a straitjacket on the conduct of a rational program of water quality management.

This disillusioning prospect should provide incentive for a revival of interest in the potentialities of watershed agencies for more efficient administration of pollution abatement. To illuminate this generalization, the following reflections will focus on

- The evolution of advocacy and response for the creation of such agencies,
- The matter in which these instrumentalities could foster least-cost programs for quality control by the application of management techniques, and
- The urgency for accommodation to regional diversity in the exercise of national regulation.

Advocacy and responses

The notion that a hydrologic unit, defined by watershed boundaries, offered a logical and viable basis for the governance of pollution control has been embraced both by theorists and pragmatists for more than 40 years. At various times the leading protagonists have included such apparently diverse interests as a national fisherman's club, a chamber of commerce, various government advisory groups, political scientists, economists, engineers, and even a U.S. president. However, aspirations harbored by these proponents seldom have generated sufficient magic to capture enthusiastic political support.

A chronology of these events can begin with a proposal in 1936 by U.S. Senator Augustine Lonergan of Connecticut. Reflecting the views of the Izaak Walton League, whose conservation efforts were oriented to clean streams, he introduced legislation calling for establishment of federally sponsored watershed authorities that would be "given the absolute power to supervise and control the purity of water" in their respective river basins.[1]

Incidently, in arguments projected by Waltonians for individual watershed management they directed attention to "what some European governments have done successfully." This displayed early appreciation of the unique characteristics of the German water boards in the Ruhr Valley, some of which were established at the turn of the century, and whose achievements to this day may be envied.

The Lonergan legislation was regarded by state governments as a radical and unwarrented federal intrusion on their sovereignty with respect to jurisdiction over waterways. Although this particular measure was rejected, it did provide impetus for congressional debate on other means for the federal government to assume leadership in pollution control efforts.

During this period, an advisory arm of the federal executive branch called the Natural Resources Board commended attention to the employment of interstate compacts as a means to effectuate river basin coordination of state pollution control endeavors.[2] This endorsement was a salutary influence on subsequent creation of congressionally approved, drainage basin regulatory agencies serving New York Harbor, the Potomac, Ohio, and Delaware river basins, and the New England area.

However, only in the case of the Delaware River compact in 1961 did the signatory parties—New Jersey, Delaware, Pennsylvania, New York, and the federal government—clothe their agency with powers broad enough to embrace an entire spectrum of management functions. All the earlier interstate agencies were limited to the role of regional coordination and promulgation of quality standards. Unlike the Delaware River Basin Commission, these other agencies were not endowed to finance, design, construct, or operate facilities. These constraints, of course, inhibited their usefulness as an instrumentality for watershed quality management.

Meantime, the recommendations of several national commissions on how to deal with water problems have consistently given cognizance to the appropriateness of watershed agencies for planning and managing such activities, including pollution control. For example, in 1949 the Hoover Commission concluded that ". . . the coordinated development of whole river basins with their watershed tributaries is peculiarly essential . . ."[3] In 1950 the President's Water Resources Policy Commission called for a coordinated attack on pollution abatement stating that "the georgraphic river basin offers the most natural area" for such an undertaking.[4]

In a 1951 critique of the above report the Engineers Joint Council[5] (whose constituents included five major engineering societies) agreed that there was virtue in regional organizations for dealing with pollution problems. More specifically, the council expressed confidence in the use of interstate compact agencies for this purpose because there could be "no overall Federal pattern to fit all streams, areas or conditions."

The most recent major report was that of the National Water Commission in 1973, prepared for the president and both houses of Congress.[6] From an assessment of institutional arrangements for regional and state management of water resources it reached the following conclusions regarding the conduct of pollution control. For intrastate areas it stated that agencies patterned after the Gulf Coast Waste Disposal Authority held much promise. (More on this agency will be related later.) For dealing with pollution problems on large interstate streams the favored instrumentality was a federal-interstate compact agency, such as the Delaware River Basin Commission. For interstate streams small enough not to substantially affect federal interests, the use of a more limited form of interstate compact was recommended.

Finally a significant event in this chronology occurred in 1966, shortly after a broadening of federal jurisdiction and subsidies for pollution control. Taking note of the commitment of substantial financial aid, President Lyndon Johnson sent a message to Congress in which he asserted that "the development of new knowledge and new organization to carry on this work is as crucial as our dollars." He then proposed that demonstration projects be undertaken with institutional arrangements designed to integrate all pollution control activities in a single river basin. Toward this end he suggested that state and local participation might be "based on an interstate compact, a river-basin commission or even a conservancy district."[7]

How might one sum up response to this many-faceted advocacy for establishment of watershed management institutions? Broadly stated, realization has fallen far short of aspirations. Of the few agencies that have been created it can be said that their political birth was painful and prolonged, and that their subsequent performance was thwarted because of limited authority and meager budgets. With respect to interstate compact commissions, their effectiveness hinged on capability of the signatory parties to "faithfully cooperate" for achievement of mutual objectives. All too often this cooperation requires a subordination of cherished prerogatives and parochial interests that do not lend themselves to easy accommodation.

Not the least of current inhibitions on the creation and functioning of watershed quality agencies are the overriding restraints imposed by federal fiats and subsidy arrangements. These have had the counterproductive effect of emasculating regional initiatives and denying the deployment of innovative practices.

Mid-century promise and frustration

The federal presence in pollution control administration—although a dominant factor in other water resources development—did not emerge until 1948. It came at a time that was coincident with activity among a number of states to devise an alternate strategy to federal intervention on matters relating to pollution of interstate waterways. Indeed, on the very day (June 30, 1948) that President Harry Truman signed the first federal water pollution act, the governors of eight states in the Midwest were signing the largest interstate compact in the nation. This event, which created the Ohio River Valley Water Sanitation Commission, was the fulfillment of a decade of negotiations sponsored largely by the Cincinnati Chamber of Commerce.

The mid-century period could be categorized as an era of promise for the protagonists of regional pollution control agencies. Four major interstate compacts already had been consumated and negotiations for a fifth were well underway. These latter efforts, resulting in establishment of the Delaware River Basin Commission in 1961, offered the greatest promise. This instrumentality was given responsibility to engage in all aspects of regional water resources development, and it was specifically charged with authority to plan and implement a comprehensive system of quality control measures within a four-state area. For this purpose it has the power to finance, acquire, design, construct and operate whatever facilities may be deemed most efficient for achieving desired objectives.

No other prior compact agency was armed with a similar mandate and the tools to execute it. Furthermore, the drafters of the Delaware compact took into account the pervasive influence of federal water resources endeavors. Thus it became the first interstate agency to include the federal government as a signatory party with participating responsibility equivalent to that of the member states of New York, New Jersey, Pennsylvania, and Delaware. If one were to seek a model of what might constitute an appropriate instrumentality for quality management in a major river basin, the Delaware Compact would have many attractive features.

For smaller intrastate streams, the model for an institution adaptable to water quality management might be found in watershed agencies of the type pioneered by the Miami Conservancy District in Ohio and now being used in parts of Texas. They are constituted to plan comprehensively, to build and operate facilities, to finance projects through assessment and service charges, and to otherwise be responsive to the solution of pollution problems common to the area.

The Miami Conservancy had its origin 66 years ago as an agency to provide flood protection.[8] Following its 50th anniversary in 1964 there was considerable interest in broadening its capabilities for pollution control. This led the district to undertake limited engineering and economic appraisals of alternative systems for quality management throughout the watershed. However, the only component that has been implemented thus far is construction of a wastewater treatment facility to service several municipalities and industries.

In 1969 the Texas legislature approved two acts to promote regional management of waste disposal.[9] One of these confers broad powers for water quality protection on some 15 river authorities and more than 500 districts. The other act created the Gulf Coast Waste Disposal Authority, which conducts all liquid and solid wastes disposal in a three-county area. It may acquire, construct, operate, or lease facilities to service the needs of individuals, the public, or private corporations in the district. Its powers include the establishment of quality standards for all waters in the area.

Unfortunately, these existing institutions and their potential for tailoring pollution control measures to drainage basin variables have largely been overwhelmed in the stampede for centralization of authority in a federal bureaucracy. In retrospect, it appears that the tremendous logistical tasks confronting that bureaucracy could have been eased by a strategy that would have harnessed rather than bypassed the knowledge and experience possessed by these regional agencies.

In contrast to the situation in the U.S. the thrust of developments in Europe have favored establishment of drainage basin entities. The classic and the most sophisticated examples are the watershed agencies in the Ruhr Valley of Germany, the earliest of which was established in 1904 and the latest in 1958. With a history of management accomplishments progressively advanced since the turn of the century, they offer practical demonstrations of how to apply scientific, technologic, and economic principles for optimum management of water resources.[10]

In France, too, aspirations for more effective pollution control has found expression in legislation adopted in 1964, which provides for establishment of drainage basin agencies.[11] They are endowed with powers to plan and finance comprehensive programs and to impose general levies as well as effluent taxes to implement corrective measures.

The most recent and largest endeavor toward basin management was launched in England and Wales in 1973. Here several thousands of water supply and wastewater undertakings have been grouped under the administration of 10 regional authorities whose boundaries of jurisdiction encompass watershed areas.[12] This development can be regarded as further refinement of traditional English practice looking toward consolidation of pollution control activities under the direction of river authorities. Prior to the 1973 reorganization, there were 27 river boards, the oldest of which, the Thames Conservancy, had been in operation for more than a century.

In brief, developments in several European countries have recognized the logic and merits of drainage basin administration as opposed to centralization of decision making in a national bureaucracy.

Concept and practice of quality management

Pollution control administration that relies exclusively on the imposition of arbitrary treatment requirements applied uniformly to all wastewater discharges can hardly be regarded as a rational strategy for coping with contemporary water quality problems. It ignores the diversity of physical factors and hydrological conditions that distinguish individual drainage basins, and it denies the opportunity to choose from among a variety of technological options that are best suited to mitigate quality degradation and the costs associated with remedial measures.

An alternative strategy to compensate for these deficiencies may be found in the application of management techniques for quality control. The *concept* embraces the conduct of a systematic search for and the evaluation of all feasible options for achieving specific goals. The *practice* of quality management calls for institutional capability to use whatever combination of facilities and operating practices that will produce desired results at the lowest overall social cost.

A most persuasive exposition of this strategy may be found in a 1968 book titled "Managing Water Quality: Economics, Technology, Institutions."[15] Here the authors, Allen V. Kneese, an economist, and Blair T. Bower, a civil engineer, convincing outline the shortcomings of conventional regulatory practices and painstakingly demonstrate in a series of case histories how these deficiencies may be remedied.

In recent years substantial contributions have been made in devising analytical, tactical, and technological procedures for managing quality. However, in the absence of an appropriate institutional framework to apply them, their usefulness is limited. To illustrate the nature of these contributions to management of quality, certain events in the Ohio, Delaware, and the Potomac drainage basins can be cited along with more recent assessment techniques demonstrated by the U.S. Geological Survey (USGS).

ORSANCO experiences.—In the early 1950s, the interstate Ohio River Valley Water Sanitation Commission (ORSANCO) pioneered in several tactical undertakings that offered at least rudimentary definition and structure to the then somewhat nebulous concept of quality management.[14] The first of these undertakings was the inauguration of a network of monitoring stations to gain some insight of daily variations and trends in quality conditions. Supplementing this manual system of data collection was the subsequent development of a unique robot monitor. These devices could measure hourly changes in several quality characteristics that were transmitted immediately to a central headquarters for surveillance and diagnostic purposes.

Prompt knowledge of quality changes combined with capability to manipulate corrective measures are basic operational tools in any scheme of management. Equally important toward this end is the availability of knowledge on impending variations in the quality of river dilution water. To satisfy this need ORSANCO enlisted the skills of the U. S. Weather Bureau. The bureau devised a means whereby it could provide data daily on the amount of flow passing various points along the 1 600-km (1 000-mile) main stem of the Ohio as well as offer a forecast of what changes could be expected over the following 3 days. Obviously, this type of advance information greatly enhances management potentials.

Reinforced with this kind of information, ORSANCO then discussed with the Corps of Engineers what possibilities existed for integrating releases of dilution water from corps storage reservoirs with quality variations in the river. On the average, these releases from upstream flood control reservoirs during periods of drought have doubled flow in the Ohio River. Eager as the corps may have been to accommodate the aspirations of ORSANCO for scheduling flow releases as needed to improve the assimilative capacity of the river, it was legally constrained at that time to make releases only in accord with flood control and navigation requirements. However, the corps was able to make a contribution to improving assimilative capacity of the river by operating discharge gates at navigation dams in a manner as to induce oxygenation of water flowing under them.

Speaking of oxygen supplementation, ORSANCO conducted a trial with a private operator of a hydropower plant at a Kanawha River navigation dam to "bleed" air into the water turbines. This proved to be an effective means for increasing the oxygen content of the river for a stretch of at least 80 km (50 miles), although it did result in some loss of power generation. The object of this demonstration, which had been inspired by much earlier trials in Wisconsin, was to encourage consideration of such arrangements at low-head power generation facilities being contemplated at Ohio River navigation dams. However, a primary constraint to implementing such arrangements is the question of who will compensate the owner of the facility for loss of electrical capacity. Such compensation could be provided by federal subsidy (which is not now available) or by contract with a watershed authority clothed with the requisite powers to finance the purchase of what amounts to a public benefit.

Finally, with respect to the ORSANCO exploration of quality management potentials, mention should be made of its efforts to "systematize" the control of brine discharges. This staff proposal stemmed from concern on how to deal equitably with increasing requests from chemical industries in various parts of the basin to discharge salt residues. The problem centered on how to avoid future deleterious effects from the buildup of salt concentrations during short periods of low river flows and yet provide for utilization of the assimilative capacity otherwise available during the greater part of the year.

Findings from the monitor system revealed the range and distribution of salt concentrations at various times in the river and how they were inversely proportioned to the availability of dilution water. Therefore, to manage quality degradation, two options were available: either place limits on all brine discharges based on arbitrary river quality standards; or prescribe a programmed discharge schedule for each source referenced to variations in the availability of dilution water.

The first option conformed with conventional regulatory practice. The second option—which introduced the application of management principles for integrating discharges of salt in accord with river flows—constituted such a departure from orthodox practice that it was not readily favored by state regulatory agencies represented on ORSANCO. However, after brine-producing industries were invited to participate in debate on the issue, a conclusion emerged that there was merit in the installation of waste-holding lagoons to permit the exercise of proportional discharge.

The commission gave approval to this procedure in 1958. By then, requests for brine discharge permits had tapered off and quality conditions with respect to salt content in the main stem of the river did not appear to be worsening. Consequently, the commission lacked incentive to implement the procedure. However, this exercise did evoke the comment that it "represents the first effort in the U.S. to view a waste disposal problem on a fully basin-wide basis and to articulate waste discharge at all points with a regional water-quality objective." [15]

Delaware estuary studies. What must be regarded as an important contribution to analytical examination of quality management alternatives is contained in a 1966 report on the Delaware River estuary developed by the Federal Water Pollution Control Administration.[16] The analysis was based on mathematical modeling of pollutional discharges and their impact on the assimilative characteristics of the waterway.

This evaluation was utilized to derive several "packages" of waste-treatment combinations that would achieve varying levels of quality in the waterway. Additionally, each proposal was accompanied with estimated costs and an approximation of monetary benefits. From this catalog of choices it was revealed that adoption of the package offering the greatest quality improvement would cost $466 million, but the benefits (largely recreational) averaged only $255 million.

In descending order of quality achievement the respective average costs and benefits of other packages were $265 and $230 million, $120 and $220 million, and $97 and $220 million. These estimates were not credited with being as accurate as might be preferred. However, they did introduce a quantifiable basis for improving the decision-making process. At hearings conducted by the commission, public support favored the program costing $120 million.

The Delaware study provided only limited exploration of measures other than treatment of wastes for enhancement of quality conditions. One of these alternatives—mechanical reoxygenation applied to certain stretches of the estuary—showed the greatest promise in offering a least-cost method of maintaining dissolved-oxygen quality objectives.

Potomac estuary analysis. The Delaware studies prompt some comment on a Potomac estuary analysis by Robert K. Davis of Resources for the Future, Inc. In 1968 he completed a study on the range of technological choices for maintaining various levels of dissolved oxygen in the estuary.[17] Using a mathematical model similar to that employed on the Delaware investigations, Davis developed a computer program wherein he simulated the comparative effectiveness and costs of some 300 systems for meeting dissolved oxygen objectives. His aim was to determine if a currently proposed method for dealing with dissolved-oxygen deficiencies in the estuary—namely conventional waste treatment coupled with flow augmentation—was indeed a low-cost solution for the problem.

From this broad array of single and multiple processes that might be applied to produce equivalent results with respect to meeting a dissolved oxygen criterion of 4 mg/l, the costs (capital, operating, and maintenance) of alternative systems ranged from $22 to $146 million. The lowest cost alternative was mechanical reoxygenation, a finding that paralleled an earlier conclusion by the Delaware analysts.

It must be recognized that these findings stem from theoretical appraisals. Substantial uncertainties could be attached to the cost and performance capabilities of any of the processes because they had not yet undergone full-scale demonstration. Nevertheless, the implication of an almost seven-fold differential in costs does compel consideration of alternate ways to achieve desired results.

USGS assessment program. Perhaps the most auspicious contribution to refinement of a rational scientific basis for quality management is the river quality assessment program being conducted by the U.S. Geological Survey. Inaugurated in 1973 with a $500 000 study of the Willamette River in Oregon, the program now embraces investigations on 6 other drainage basins, the largest of which is a $5 million assessment of the Potomac Estuary.

The thrust of the program is to provide practical demonstrations of how to define the character, interrelationships, and causes of river-quality conditions; and to devise appropriate methodology for the collection and evaluation of information that is needed to appraise the nature of quality problems and alternative means for dealing with them. Details on the conduct of this ambitious undertaking and results achieved are set forth in the 1977 proceedings of a symposium conducted by the American Water Resources Association.[18]

Suffice it to say here that what has

emerged is an illumination of the unique characteristics of individual drainage basins and what potentialities exist for manipulating conditions to attain desired quality. For example, on the Willamette watershed where secondary treatment facilities had been installed at all municipal and industrial wastewater discharges, a problem of dissolved oxygen deficiency during the summer months continued to exist. To cope with this, the Oregon authorities contemplated that the only recourse would be to impose tertiary treatment requirements on all discharges. However, the USGS studies revealed that this expensive form of advanced waste treatment would not appreciably improve conditions. One reason was that almost half of the oxygen demand originated from natural runoff to the river for which there was no immediately available method of control. But the major factor was discovered to be discharge of ammonia, which was utilized in waste treatment employed at pulp and paper mills. Thus the remedy was not to be found in tertiary treatment for all waste discharges but in the elimination of ammonia mostly from a single source.

Shortly after publication of these findings the Comptroller General, in a 1976 report[19] to Congress, questioned the wisdom of providing additional federal subsidies for advanced waste treatment. To support his views he cited the Willamette assessment in these terms, "The study did not require a great deal of money but it is only a fraction of the tens of millions of dollars it would have cost to install advanced waste treatment facilities . . . ." Perhaps no greater accolade could have been bestowed on the USGS river quality assessment efforts. Incidently, Congress reacted to the Comptroller General's recommendation by placing restrictions on installation of further advanced waste treatment projects in all parts of the nation.

In the meantime, another USGS study of the Chattahoochee River basin in Georgia is focused on an assessment of urbanization and hydropower operations on river quality. Here again, findings confirmed that upgrading treatment of wastewaters beyond secondary levels would not contribute materially to quality enhancement. Approximately half of the total nitrogen and phosphorus found in the river below the area of major urban development is from non-point sources; three-quarters of the dissolved solids and toxic metals in the river originate from these same sources. Additionally, releases of water from hydropower operations in the upper river, if properly scheduled, were shown to have a substantial beneficial effect. In part, these flow releases negated the heat loadings contributed by downstream thermoelectric generating facilities, which in turn had been a factor in depressing oxygen levels.

These two examples illustrate the pragmatic character of the USGS approach for developing appropriate management strategies. Not the least of its distinguishing features is that the basic methodologies being demonstrated can be flexibly adapted to assessment procedures in any drainage basin. Thus the projects already underway not only are providing information currently applicable to specific problem situations but are serving as a training opportunity for a new breed of quality management specialists.

It would be an injustice not to mention that in developing its program, the USGS had acumen to recognize the virtues of the classic analytical procedures pioneered some 30 years ago by Clarence J. Velz, now professor emeritus, University of Michigan.[20] Dr. Velz has been a consultant on all the projects since their inception and has been honored with the John Wesley Powell Award of the U.S. Geological Survey.

In summary

Among the conclusions that may be drawn from this historical perspective there are three that have relevance to prospects for future realization of watershed quality management.

The first is that substantial progress has been made in methodology for diagnosing the causes, nature, and scope of quality degradation in surface waters.

The second is that there is demonstrable economy justification for consideration of a range of technical options and operational tactics to mitigate the undesirable aspects of pollution and otherwise maintain appropriate quality conditions.

And finally, the institutional framework of several existing watershed entities suggests they could readily be adapted to the exercise of quality management functions provided federal policy was hospitable for harnessing them to this task.

However, national legislation does not accommodate to these perspectives. It seeks to attain clean water goals by relying primarily on the application of uniform treatment requirements to all wastewater discharges. While the intention of this policy is to simplify administrative control of pollution and to expedite such action with federal finding of 75% of the most of municipal treatment facilities, the results leave much to be desired.

Among the problems has been the overburdening of a new centralized buraucracy whose competence has been sorely tried to draft the myriad of mandated procedures within an unrealistic time frame. Approval of projects has been delayed, funding has been tardy, and the program is bogged down in a maze of litigation and uncertainties. All of these difficulties and more is confirmed in a recently published interview with John Quarles, former deputy administrator of the U.S. Environmental Protection Agency, (EPA) and Thomas Jorling, former assistant administrator for water and waste management of EPA.[21]

Anticipating that problems would emanate from what was characterized as a legislative "venture into an area of many unknowns," Congress included authorization in the 1972 act for a later study to identify the need for any mid-course adjustments. In 1976 recommendations for policy changes did come forth in a report of the National Water Quality Commission, following an investigation that cost $17 million.[22]

Ten of the 15 members of this commission were Congressmen who had played an active role in drafting the legislation; the chairman was the vice-president of the U.S. and the other 4 members included representatives from a state, a municipal agency, an industry, and a private water resources specialist. One of the most influential members of Congress, then Senator Edmund S. Muskie, chose to "disassociate" himself from the recommendations although he did agree that the data would be useful for evaluating proposed changes. Other congressional members expressed reservations, particularly with respect to suggested modification of technology-based effluent requirements. This reluctance among drafters of the legislation to accept substantial adjustments obviously reflected continued confidence in their original convictions.

However, recommendations did result in some amendments to the act that relate primarily to administrative details, funding provisions, and increased attention to toxic pollutants. But the 1977 amendments did not revise the basic thrust of the regulatory strategy adopted in 1972. In fact, two recommendations that could have been specifically construed as favoring attention to watershed quality management principles were discountenenced.

One of them called for delay in mandating successively higher levels of treatment technology until it was possible to make a judgment on what had been accomplished by compliance with initial effluent control requirements, namely, installation of secondary treatment or its equivalent for all municipal and industrial discharges. This recommendation argued that in some situations only marginal benefits would accrue from insisting on universal application of more intensive end-of-pipe treatment until measures had been taken to deal with stormwater runoff, agricultural drainage, and other non-point sources of pollution. The basis for this contention was increasing evidence that in many waterways perhaps half or more of quality degradation originated from such sources. In brief, even if all end-of-pipe discharges were completely eliminated, only half of the pollution problem would be corrected.

Another recommendation dealt with what was termed "an obvious necessity" for a shift toward decentralization of decision-making and execution of the national program, which is concentrated in Washington, D.C. The logic for this was stated as follows, "The diversity of water pollution problems across the country dictates that cost-effective solutions to problems be developed at local and regional levels."

This statement once again re-echoes a sentiment that has been espoused for almost half a century. And it comes at a time when economic and social circumstances have never been more compelling for an aggressive display of professional initiative for the practice of watershed quality management.

Edward J. Cleary has served as executive director and chief engineer of the Ohio River Valley Water Sanitation Commission (ORSANCO) from its establishment in 1948 until his retirement in 1967. Created by eight states, ORSANCO is one of the largest watershed quality control coordinating agencies in the nation. Currently, Cleary is a professor emeritus of the University of Cincinnati, where he was engaged from 1955 until 1975 in the teaching of environmental quality management. He has participated in consulting assignment with a number of national and international organizations.

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NATIONAL WATER QUALITY INVENTORY: 1982 REPORT TO CONGRESS

Office of Water Regulations and Standards (WH-551)
Environmental Protection Agency
Washington, D.C. 20460

EPA 440/2-84-006
February 1984

This report was prepared pursuant to Section 305(b) of the Clean Water Act, which states:

"(b)(1) Each State shall prepare and submit to the Administrator by April 1, 1975, and shall bring up to date by April 1, 1976, and biennially thereafter, a report which shall include—

"(A) a description of the water quality of all navigable waters in such State during the preceding year, with appropriate supplemental descriptions as shall be required to take into account seasonal, tidal, and other variations, correlated with the quality of water required by the objective of this Act (as identified by the Administrator pursuant to criteria published under section 304(a) of this Act) and the water quality described in subparagraph (B) of this paragraph;

"(B) an analysis of the extent to which all navigable waters of such State provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allow recreational activities in and on the water;

"(C) an analysis of the extent to which the elimination of the discharge of pollutants and a level of water quality which provides for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allows recreational activities in and on the water, have been or will be achieved by the requirements of this Act, together with recommendations as to additional action necessary to achieve such objectives and for what waters such additional action is necessary;

"(D) an estimate of (i) the environmental impact, (ii) the economic and social costs necessary to achieve the objective of this Act in such State, (iii) the economic and social benefits of such achievement; and (iv) an estimate of the date of such achievement; and

"(E) a description of the nature and extent of nonpoint sources of pollutants, and recommendations as to the programs which must be undertaken to control each category of such sources, including an estimate of the costs of implementing such programs.

"(2) The Administrator shall transmit such State reports, together with an analysis thereof, to Congress on or before October 1, 1975, and October 1, 1976, and biennially thereafter."

United States
Environmental Protection
Agency

Washington DC
20460

EPA

The Administrator

Dear Mr. President:
Dear Mr. Speaker:

As required by Section 305(b) of the Clean Water Act of 1972 (P.L. 92-500) and its 1977 amendments, I am transmitting to the Congress the National Water Quality Inventory Report for 1982. This report is the third in the series of national inventory reports published since 1976. It is based primarily on reports submitted by the States in 1982, with additional information from 1980 reports wherever gaps exist in the 1982 submissions. The 1980 and 1982 State reports are being transmitted to the Congress in their entirety.

The 1982 State Section 305(b) reports reveal that water quality is improving in many States. In fact, the majority of the Nation's waters assessed in 1982 meet the interim Clean Water Act goal. Many water quality improvements can be directly attributed to pollution control programs. For example, 36 States cite specific improvements resulting from the construction of municipal wastewater treatment facilities, and 20 States report improved water quality due at least in part to pollution controls implemented by industry. A number of successes in nonpoint source pollution abatement are also reported, although the effects of nonpoint controls tend to be difficult to quantify.

Despite this progress, point and nonpoint sources of pollution, as well as other factors such as natural variation in stream flow and hydrologic modifications, continue to cause violations of water quality standards and are limiting water uses in many areas of the country. Two issues of national concern are pollution resulting from toxic substances, and ground-water contamination and depletion. Thirty States cite violations of water standards or impairments of water uses due to toxic substances. Ground-water problems due to contamination or depletion are reported in over half the States.

These results demonstrate that the basic structure of the Clean Water Act is sound. That is, the dual emphasis on technology-based controls—uniform national requirements for point sources—and on water quality-based controls, which are imposed only where technology-based controls are inadequate, has resulted in dramatic progress. EPA's current programs to implement the Clean Water Act focus on two key objectives:

- Continue to develop and implement technology-based controls. EPA is actively developing the national regulations to control the industrial discharge of toxic pollutants, and with the States will move rapidly to clear the backlog of permits which must be issued to implement these controls.
- Strengthen the water quality-based approach so it will be available where needed to control point sources of pollution in the areas where technology-based controls are not sufficient to achieve water quality standards.

EPA is also beginning to focus greater attention on nonpoint sources of pollution. A national nonpoint source implementation policy is being developed, and various State and local efforts are already underway which should increase our understanding of the causes and effects of nonpoint source pollution.

The primary sources of information for this report are the water quality monitoring programs operated by the States. Many of these programs are currently undergoing a transition from traditional chemical water quality analyses to a more comprehensive combination of biological, physical, and chemical analyses. Therefore, the conclusions expressed in this report, which still rely heavily on traditional measures of water pollution, may change in future reports as better information is generated through expanded monitoring efforts. EPA will continue to work with the States in developing and improving future reports in this series.

Sincerely yours,

William D. Ruckelshaus

Honorable George Bush
President of the Senate
Washington, D.C. 20510

Honorable Thomas P. O'Neill, Jr.
Speaker of the House of Representatives
Washington, D.C. 20515

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Preface

This document, the third in a series of National Water Quality Inventory reports published since 1976, is based on water quality reports to the Congress submitted by the States and other jurisdictions of the United States in 1982. In some cases, State-reported information is supplemented by Environmental Protection Agency (EPA) data, particularly where national program issues are discussed. Because no National Water Quality Inventory report was published in 1980, information from the 1980 State reports is included in this document where 1982 data are lacking.

The State water quality reports, which provide descriptions of the water quality of all navigable waters in the individual States, are prepared biennially pursuant to Section 305(b) of the Clean Water Act. In 1982, 55 of a total of 58 States and jurisdictions submitted reports. The submissions from the States and jurisdictions are being transmitted to the Congress in their entirety with this report. A summary of each State's submission is included in Appendix B.

Section 305(b) of the Clean Water Act requires each State to submit a biennial report to the EPA describing the quality of its navigable waters. This report is to include the following: an analysis of the extent to which the State's waters provide for healthy fish, shellfish, and wildlife populations and allow water-based recreation; an analysis of the extent to which pollution control actions have achieved this level of water quality, and recommendations for needed additional actions; an estimate of the environmental impacts, economic and social costs and benefits, and date of achieving this level of water quality; and a description of the nature and extent of nonpoint sources of pollution and recommendations for their control. The EPA is required to transmit the State reports to Congress, along with a summary of these reports describing the quality of the Nation's waters.

The State Section 305(b) reports tend to focus primarily on the quality of inland waters and, in particular, on rivers and streams. Some States discuss lake quality and ground water, and some coastal States emphasize water quality issues in selected bays or estuaries. Because such coverage is incomplete in other States, however, this report does not attempt to analyze coastal areas, wetlands, ground water, and lake quality at length.

1

Introduction and Overview

Background of the 1972 Clean Water Act

The Federal Water Pollution Control Act Amendments of 1972 (the Clean Water Act) were passed at a time when serious water quality problems existed in many parts of the country. For example:

- In the 1960s, Ohio's Cuyahoga River and New York's Buffalo River were so oil-slicked and polluted they actually caught on fire. The Houston Ship Channel, the Calumet River, and many other waterways were plagued by poorly treated or untreated municipal and industrial wastes.
- In 1968, over 44 million people were served by municipal wastewater treatment facilities which provided only primary levels of treatment.* Sewage from over ten million people received no treatment and was discharged directly into the Nation's waters.
- Many States had only limited controls on industrial discharges, and no uniform, national approach existed to regulate the quality of industrial discharges.
- Our knowledge of a number of possibly significant problems, such as the prevalence of toxic substances in the Nation's waterways and the contribution of nonpoint sources of pollution to water degradation, was very limited.

The Congress passed the Clean Water Act in 1972 to deal with these problems. The Act establishes two types of regulatory requirements: technology-based guidelines, which set uniform national requirements for discharges by industries and sewage treatment facilities; and water quality-based standards adopted by the States.

The EPA is required to establish uniform national technology-based requirements which apply to municipal and industrial point sources of pollution. For municipalities, the technology-based standard is commonly referred to as secondary treatment. For industrial discharges, technology-based requirements are referred to as best practicable treatment (BPT), best conventional technology (BCT), and best available technology (BAT). The primary bases for adoption of these requirements are available or demonstrated treatment technologies and costs. These technology requirements are embodied in federal regulations and are incorporated into National Pollutant Discharge Elimination System (NPDES) permits issued in accordance with Title IV of the Clean Water Act.

Technology-based guidelines set uniform national requirements for a specific industrial category. These requirements vary from industry to industry. For example, the steel industry is regulated differently than the textile industry because of the differences in waste generated by each, and the technologies which are available to control these wastes. Moreover, different requirements exist even within an industrial category. The steel industry, for example, has 52 subcategories, each of which have somewhat different requirements. Different types of municipal sewage treatment systems, such as lagoons and activated sludge treatment plants, also have different technology requirements.

Every municipal and industrial point source discharger is required to meet these minimum technology-based requirements with a few limited exceptions. Permits are issued to the owners or operators of municipal or industrial facilities which specify discharge limits in terms of a maximum concentration, mass loadings, or both. Discharge of pollutants from a municipal or industrial facility without a permit or in violation of any of the conditions of a permit (including failure to monitor the discharge and report such monitoring data to the State or EPA) is a violation of the Clean Water Act.

Water quality standards are the second regulatory requirement established by the Act. These standards have a different focus than the technology-based requirement. Under Section 303 of the Act, States are required to adopt water quality standards as State rules or laws. Water quality standards define the uses to be made of water (such as public water supply, propagation of fish and wildlife, recreation, agricultural and industrial purposes, and navigation) and the criteria to protect the uses. Criteria are acceptable qualitative or quantitative estimates of water constituents which should ensure that the use is attained.

Currently, all States and jurisdictions have approved water quality standards. For most waters, these standards include a fish and wildlife protection use, commonly referred to as a "fishable" use. Only eight States have some waterbodies which are not assigned "fishable" uses. All State standards include criteria for "traditional" constituents such as temperature, pH, dissolved oxygen, fecal coliform bacteria, and the "free froms." "Free froms" are general narrative criteria statements directed at controlling aesthetic qualities such as taste, odor, color, and other elements including settleable solids, oil, and toxics.

Water quality standards serve three important functions under the Clean Water Act. First, they establish a goal for a particular stream or waterbody. This goal is expressed as a use which is to be attained or protected and a level of water quality which is to be achieved. Second, water quality standards, through the water quality management process, assist the States in making management decisions for setting priorities, developing and implementing programs to control nonpoint (diffuse) sources of pollution, and evaluating the progress of water pollution control programs. Finally, and most importantly, water quality standards serve as a regulatory tool. National technology-based standards are applied regardless of the type of waterbody or the quality of the water receiving the discharge; therefore, the pollution reduction resulting from those requirements for a particular stream may be inadequate to protect designated uses in State water quality standards. For such cases, permits written on the basis of water quality standards provide the additional level of protection needed to protect or restore the designated use.

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*See glossary for definition of terms

To implement these two regulatory requirements, the Act also establishes several processes including a discharge permitting program, a program of grants for the construction of sewage treatment facilities, and a basic approach encouraging best management practices for the control of nonpoint source pollution.

Summary of Progress to Date

The data provided by the 1982 State Section 305(b) reports, together with other EPA information, show what changes have occurred in water quality and in abatement and control programs since 1972. This information indicates that the basic approach to pollution control envisioned in the Clean Water Act is working.

Pollutant reductions have occurred. Substantial reductions have occurred in the amounts of pollutants that would otherwise have entered the Nation's waters:

- Implementation of BPT regulations is estimated to have reduced industrial discharges of six key pollutants substantially from 1972 to 1977: biochemical oxygen demand (BOD) by 71 percent; suspended solids by 80 percent; oil and grease by 71 percent; dissolved solids by 52 percent; phosphate by 74 percent; and heavy metals by 78 percent.

- Sewage treatment plants are removing about 13,600 tons per day of the two principal conventional pollutants, BOD and suspended solids. This is an increase of 65 percent over 1973 levels. The reason for the increased pollutant removals is that with the help of construction grants, increasing numbers of major municipal treatment plants are achieving secondary treatment levels. In July 1977, 37 percent of the secondary plants required by the Clean Water Act had been constructed; by June 1983, that number had risen to 69 percent.

- The increased treatment levels in municipal wastewater treatment plants (WWTPs) have offset the increase in pollutant loads that has occurred because of increasing population, new sewers, and population shifts. In other words, the total amount of pollutants entering the Nation's waters from WWTPs has stayed roughly constant in the last decade, even though the population served increased by 18 million and municipal wastewater flow increased by almost 7 billion gallons per day.

Compliance rates are improving. Achieving municipal and industrial compliance with permit limits is a central goal of the Clean Water Act and a crucial reason for its success. EPA data show that the percentage of major municipal treatment plants in significant non-compliance with their permits decreased from 27 percent in 1981 to 22 percent by December 1982. Significant progress has been made in the reissuance of operating permits for municipal plants, although backlogs continue, in particular for minor plants. The percentage of major industrial plants in significant non-compliance decreased from 18 percent in 1981 to 15 percent by December 1982. Progress has been made in the reissuance of industrial permits, although the current backlog of permits which must be reissued is expected to grow as previously-issued permits expire. Again, minor dischargers form the bulk of the backlog.

Nonpoint source controls are being applied. Progress has also been made in the application of nonpoint source controls. Forty-seven States have approved agricultural nonpoint source programs and 39 States are taking implementation actions. Sixteen States are implementing regulatory sediment and erosion control programs to control the runoff of pollutants from construction activities. Thirty-seven States have silvicultural nonpoint source control programs, varying in nature from regulatory (including forest practice acts) to nonregulatory (for example, education and technical assistance).

Progress is being made in controlling toxic pollutants. EPA studies and sampling efforts show that current BPT discharge limits and existing BPT permits are removing significant amounts of a number of toxic organic chemicals and heavy metals from industrial discharges. Furthermore, a survey of wastewaters entering and leaving municipal sewage treatment facilities reveals that well-operated plants meeting secondary treatment requirements provide incidental removal of priority pollutants such as heavy metals and organics. Nevertheless, as will be discussed below, toxic pollutants continue to cause water quality problems in many areas.

Overall water quality is improving. The State Section 305(b) reports indicate that the Nation's water quality is beginning to show improvements as a result of the above actions. One of the primary measures of water quality status is the States' estimate of progress toward the interim goal of the Clean Water Act: that, wherever attainable, water of fishable and swimmable quality be achieved by 1983. In 1982, a majority of the State waters which were assessed met this interim goal. (For State-by-State details, see Table 1, Chapter 3.)

Trend information from the 1982 State Section 305(b) reports reveals that progress has been made in the control of water pollution in many States. Twenty-one of the 35 States reporting overall trend information cite generally improving water quality trends. Fourteen States report generally stable trends; none report Statewide degrading trends. However, 29 States report some degrading trends in localized areas.

Control programs are producing results. The States provide many examples of water quality improvements that can be attributed directly to point and nonpoint source control programs. For example, thirty-six States cite improvements in their waters as a direct result of the construction of wastewater treatment facilities. Twenty States cite improvements in water quality attributed at least in part to industrial controls. And, although the impacts of nonpoint source control programs can be difficult to quantify, some States report successes in nonpoint source abatement in 1982.

Problems Which Remain

State-reported water quality information, together with EPA information, indicate that there are a number of pollution problems which remain to be solved. For example:

- Municipal and industrial dischargers continue to cause violations of existing water quality standards in a variety of areas in almost all States.
- Most States are affected to some degree by nonpoint sources such as runoff from agricultural operations and acid mine drainage from abandoned mines. In many cases, these sources contribute significantly to the impairment of water uses; in fact, in about one-fifth of the States, nonpoint sources are cited as the most important cause of water degradation.
- Thirty States cite water quality problems due to toxic substances. These toxic substances can come from a variety of sources such as industrial operations, agricultural runoff, and solid waste disposal activities. Because of the tendency of some toxics to accumulate in fish tissue, fishing bans and fish consumption warnings are in effect in a number of waters such as New York's Lake Ontario and Upper Hudson River, and Michigan's Saginaw and Tittabawassee Rivers.
- Ground water problems—due either to contamination or depletion—are reported in over half the States. The most commonly reported causes of ground water problems are waste disposal, landfill leakage, septic tank discharges, and overdrafting.
- States report that excessive nutrient levels are a widespread problem. High nutrient levels particularly affect standing waterbodies such as lakes, and can impair a variety of water uses such as fish propagation and water-based recreation.
- Thirty-seven States report that their waters are affected to some degree by factors other than point and nonpoint source discharges. These factors include flow variations, dam releases, hydrologic modifications such as channelization of streams, and natural conditions.

Implications for National Programs

Implementation of technology-based controls has improved the quality of many of the Nation's rivers and streams. As mentioned previously, a majority of the Nation's waters already meet the 1983 goal of fishable/swimmable quality. Further improvements may be expected as the latest round of BAT regulations are implemented. Nevertheless, some of the Nation's waters will require additional water quality-based controls. The problems in these waters are likely to be among the most difficult to address, especially if they are caused by toxic substances, nonpoint sources, or other factors such as low flow which limit the available capacity of the waterbody to assimilate pollutants. Future progress will depend to an increasing degree on development and implementation of water quality-based controls.

The emphasis given in the 1970s to developing technology-based controls and implementing a permit system meant that EPA placed less emphasis on water quality standards and the water quality-based approach. States were not provided adequate guidance for establishing water quality standards and for applying them in a water quality-based approach to pollution control. With EPA encouragement, States used standards as goals and with few exceptions, set them to reflect the fishable/swimmable 1983 goal of the Act; in many cases there was little analysis of whether these uses and the criteria for meeting them were appropriate for a particular body of water. On the whole, few site-specific analyses were conducted even though, under the Clean Water Act, standards were intended to reflect specific local conditions and priorities. The States were not provided with much information on implementation of water quality standards through the permit and construction grant processes. EPA issued limited technical guidance on how to calculate and apply appropriate models to transform water quality standards into permit limits and design criteria for treatment plants.

Thus far, water quality based-limitations have not been a major component of permits because of EPA's emphasis on the technology-based municipal and industrial components. Only 10 to 20 percent of the major industrial and municipal permits issued have a water quality-based component. Many of these permits were written before the technology-based requirements were published. However, as the technology-based requirements are completed and included in permits, greater emphasis will be placed on including water quality-based components in permits to meet water quality standards, with a particular focus on priority pollutants. In fiscal year 1984, EPA is scheduled to write a number of major industrial permits, about forty percent of which will address significant water quality-based concerns. It is not yet known how many State-issued permits will have water quality-based components, but the number is expected to increase each year.

National Program Directions

Recognizing the progress which has been made in implementing the Clean Water Act to date, and the problems with the water quality-based approach to pollution control discussed above, EPA is taking the following approach in its national program directions:

- EPA will continue its emphasis on technology-based controls. Effluent guidelines to control the industrial discharge of toxic pollutants will be issued. EPA, with the States, will move rapidly to clear the backlog of permits which must be reissued to implement these regulations.
- The water quality-based approach will be strengthened. It can then be applied effectively where needed to control point sources of pollution in the areas that will not meet the fishable/swimmable goal with technology-based controls alone. In addition, EPA will provide the necessary guidance to encourage State and local implementation of nonpoint source controls where needed to achieve or maintain high levels of water quality.

EPA provides national direction for carrying out water quality programs through its Office of Water Operating Guidance and Accountability System. This guidance describes the general approach to be followed in developing and implementing each water program, and outlines an overall management and program evaluation framework. These program and management approaches should form the basis for long term program planning by EPA and State water pollution control agencies. Chapter 2 discusses national program directions in more detail.

2

National Program Directions for the 1980s

This chapter discusses EPA's national program directions for implementation of the Clean Water Act, which combine continued vigorous implementation of technology-based controls with an emphasis on water quality-based controls where necessary to achieve the fishable/swimmable goal of the Clean Water Act. These program directions will be discussed in terms of the technology-based approach (specifically, effluent guidelines) and major elements of the water quality-based approach: water quality standards; monitoring; wasteload allocations; permitting and compliance; nonpoint source control; construction grants; and priority waterbodies.

Technology-Based Approach

EPA is actively developing national regulations, referred to as "effluent guidelines," to control the industrial discharge of toxic pollutants. To date, major strides have been made in the issuance of effluent guidelines. As of December 1983, EPA had promulgated final regulations for 20 industry categories and proposed regulations for 6 others. These guidelines, designed to be environmentally sound and economically achievable, have been proposed and promulgated on schedule, pursuant to a court ordered settlement agreement. EPA will provide technical assistance to State permit writers in implementing the guidelines.

Water Quality-Based Approach

In response to the problems outlined in Chapter 1, EPA has initiated a number of activities to assist States in identifying waters which fail to meet standards after implementation of technology-based controls, and in designing appropriate control measures to ensure that standards are attained. These activities, which include issuance of revised water quality standards regulations, regulatory reforms, guidance documents, and public education, are designed to fully and effectively implement a water quality-based approach to pollution control. EPA has systematically integrated expertise and resources from various offices to better implement the water quality-based approach. EPA is also making a broad range of technical guidance available to the States. This technical guidance covers subjects such as the performance of wasteload allocations for toxic pollutants and the analysis of bioassays of complex industrial effluents. Guidance has also been drafted to assist States in using scientific and technical analyses for setting uses and criteria on a site-specific basis.

EPA's primary objective under the water quality-based approach is to provide the technical support that States need to write appropriate water quality-based permits and make nonpoint source management decisions. EPA will also help the States correlate water pollution control requirements for all sources, both point and nonpoint, with actual attainment and restoration of beneficial uses.

Related objectives are to encourage and help the States to:

- assure that limited State and local resources are directed toward the establishment of water quality-based controls on a carefully planned, priority basis;
- assure adequate control of toxic pollutants;
- provide for adequate public input/discussion throughout the planning process, including designation of beneficial uses to be protected, selection of numeric criteria to protect the designated uses, and calculation of pollutant wasteload models;
- assure the availability of adequate site-specific data for decisionmaking on designated uses and narrative/numeric criteria; and
- implement nonpoint source controls where needed.

State and local agencies will need to concentrate their efforts on highest priority waterbodies. This will require close EPA, State, and local coordination. Success depends in large measure on whether the States, on the basis of EPA policies and program/technical guidance, answer the following basic questions for water quality-limited waterbodies:

(1) What is the use to be protected?

(2) To what extent does pollution contribute to the impairment of the use?

(3) What is the level of point source control necessary to restore or enhance the use?

(4) What is the level of nonpoint source control necessary to restore or enhance the use?

Water Quality Standards

Section 303(c) of the Clean Water Act provides the basis for EPA review and approval of State-adopted or revised water quality standards. Section 303(c) requires States to hold hearings to review these standards at least once every three years and to revise standards where necessary; establishes time limits for various State and federal actions; and provides a mechanism for federal promulgation if the State's action is inconsistent with the requirements of the Act.

EPA assistance to States includes meeting with State officials before standards revisions are initiated to mutually agree upon what standards and waterbodies will be reviewed in detail. This agreement should outline the extent and detail of analyses needed to support any changes in the standards, how the analyses will be conducted, who might be participating in the analyses, the sources of existing data and information, and a schedule for completion of the analyses. EPA assists in the analyses and recommends approaches where needed and requested by the State. This process is designed to encourage a close working partnership between the States and EPA, and to assure the involvement of locally affected parties.

EPA carefully reviews State water quality standards to ensure that the standards meet the requirements of the Act. EPA verifies that beneficial uses have been designated; that the criteria to protect the designated uses are adequate; that the State has followed proper legal procedures in adopting standards; that standards not meeting the Section 101(a)(2) goals are scientifically and technically supportable; and that the State water quality standards include all necessary requirements. EPA also reviews the adequacy of the analyses in support of any changes in the standards. Where the analyses are inadequate, EPA identifies how the analyses should be improved and suggests the type of information or analyses needed. EPA also looks at whether downstream standards are protected.

Total Maximum Daily Loads/ Wasteload Allocations

Section 303(d) of the Act requires States to identify waters requiring more stringent effluent limits and to set priorities and calculate pollutant loads that will ensure implementation of water quality standards. This calculation, a total maximum daily load (TMDL), is expressed as the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint and natural background sources. Section 303(d)(1)(C) provides that TMDLs be established by the States (with EPA's review and approval) with seasonal variations and a margin of safety to take into account any lack of knowledge concerning the relationship between effluent limitations and water quality.

The results of the TMDL process are adopted in the water quality management plan for the State or area in which the stream is located, and WLAs are included as enforceable effluent limitations in permits issued to dischargers. These permits are part of the National Pollutant Discharge Elimination System, or NPDES, and are the legal basis for requiring dischargers to control the pollutant levels in their effluents. All permits are to comply with the applicable water quality standards. Under Section 401(a)(1) of the Act, States certify that the allowable discharges in permits comply with State standards.

Almost all States have TMDL/WLA programs for at least some conventional pollutants. Thirty-four States have programs currently in place that can handle most major construction grants and major industrial permits. Although these programs are generally limited to conventional pollutants, about ten States with the strongest programs are beginning to address toxic pollutants. Either pollutant-specific techniques or bioassay/biosurvey techniques can be used to establish levels of pollution control needed in order to meet the applicable water quality standards. Pollutant-specific techniques address individual pollutants; bioassay/biosurvey techniques measure the toxicity of total effluents.

Monitoring

EPA and the States must ensure that environmental decisions are based on sound scientific data and information. The EPA is encouraging States to develop a coordinated, balanced approach to water quality monitoring. Water quality data is collected by many different groups—EPA, the U.S. Geological Survey, State agencies, municipalities, local and areawide planning agencies, universities, and the regulated community—for different reasons. EPA is assisting States in establishing a coordinated monitoring program which both avoids duplication of effort and fills in the missing links in our ability to identify and characterize water quality problems and set priorities.

The EPA is emphasizing a water monitoring program which will make more effective use of local, State, and federal resources for collecting, analyzing, and interpreting monitoring data. This program will stress: (1) biosurveys and bioassays to facilitate the analysis of impaired aquatic life uses; (2) local participation in the design and implementation of monitoring programs; (3) continued use of intensive surveys to help analyze the causes and effects of water quality problems; (4) improved design and operation of monitoring programs and improved data analysis techniques; and (5) reporting formats that will meet State needs and also enable status and trend analysis to be reported on a compatible basis nationwide.

Currently, the most pressing need the States face is analyzing use impairments. However, the States have found that it is difficult to identify aquatic life impairments and threats to human health, and to evaluate the causes of use impairments in quantitative terms. This is because only about 25 States have routine biological sampling programs, although almost all States have at least some biological monitoring capabilities. Many States have been experimenting with the use of bioassays in the permitting process. Nevertheless, much work remains to be done to make better use of biological field surveys in evaluating and determining appropriate uses and criteria, and in evaluating the actual use impairments resulting from toxic pollutants and urban runoff problems. The States generally agree with EPA's emphasis on analysis of use impairments. They acknowledge a need to improve in this area and share a willingness to begin pilot efforts to gain experience in biological analyses.

EPA's Office of Water is currently developing policy and technical procedures for using biomonitoring and other techniques in setting water quality-based effluent limits. Biomonitoring includes effluent toxicity tests, bioaccumulation tests, and ecological field studies. It is an important aspect of EPA's water program because it can, in many cases, provide information about water quality impacts which cannot be obtained using other monitoring techniques. In developing biological procedures and guidelines, EPA will build upon a scientific base that has advanced significantly in recent years. EPA will work with State agencies responsible for water quality standards, planning, and monitoring to assure that maximum use is made of available data and resources in the design and implementation of field studies that may include biomonitoring.

In addition, the States and EPA are developing improved methods of reporting environmental progress. States will be placing greater emphasis on the use of Section 305(b) reports for management purposes. The Section 305(b) reports currently are primarily used for public information, emphasizing chemical trends, criteria violation analyses, and local "success stories." States will need to focus management attention on redirecting the reports to place more emphasis on site-specific cause effect relationships and analyses of impaired uses.

The Association of State and Interstate Water Pollution Control Administrators and EPA are working on a pilot project to improve the States' ability to describe their water program activities and results. This project is designed to produce a concise reporting format that will be used by the States to discuss their water program achievements since 1972. It should also result in recommendations for improving future reporting efforts.

Permitting and Compliance

One of the EPA's primary goals is to increase the involvement of State and local governments in the Agency's decisionmaking and program operation for pollution abatement and control. A major objective of the NPDES program is to assist in the development of new State programs for administering the NPDES program and necessary program modifications by States already having NPDES authority. Thirty-seven States now have NPDES permitting and enforcement authority. Direction will be given to State program approval efforts through the development of State-by-State strategies which will identify obstacles to program approval and present a workplan for overcoming the obstacles.

Municipal compliance will continue as a high priority. Implementation of State municipal compliance strategies should provide the focus for improving municipal compliance. Compliance activities will also be directed to maintain and improve the existing high rate of compliance by nonmunicipal sources. Focus will be on major permittees and their primary industry discharges, and minor permittees that are causing water quality or health problems.

The pretreatment program controls the indirect discharge of priority pollutants by industries to publicly owned treatment works. Municipalities are required to develop a program that will assure that industrial dischargers to municipal wastewater treatment systems will comply with national and industry-specific standards. The regulations require municipalities to have submitted pretreatment programs to EPA or the State for approval by July 1, 1983. By the beginning of FY 1984, 22 percent of a total of 1,675 programs had been approved by EPA and a thousand additional municipalities had submitted at least significant portions of their pretreatment programs. By the end of FY 1984, 68 percent of pretreatment programs are expected to be approved. EPA's highest pretreatment program priority in FY 1984 is completing the review of local pretreatment programs and incorporating approved pretreatment programs into municipal permits where appropriate.

The reissuance of industrial permits will also receive high priority. Priority permitting lists for major sources, developed in accordance with EPA policy, will be used where practical. Under this Policy for the Second Round Issuance of NPDES Permits for Industrial Sources (June 2, 1982), permits will be issued to industries on the basis of a priority system that gives highest priority to facilities where use impairment problems have been identified and where there is enough information to develop water quality-based permits, and to permits needed to implement the new BAT effluent guidelines.

Nonpoint Source Control

Those factors which make nonpoint source pollution difficult to understand—for example, its diffuse nature, the many sources which can contribute to any one problem, and its tendency to be associated with heavy rainfall runoff—also make prevention and control difficult. Implementation of nonpoint source control programs is the responsibility of State and local governments which must weigh the benefits of nonpoint source pollution against the benefits of other services; furthermore, it is often difficult to demonstrate the effectiveness of nonpoint source control practices. These challenges do not mean, however, that nonpoint source pollution is beyond prevention or control.

Under Section 208 of the Clean Water Act, States identified nonpoint source problem areas and developed appropriate solutions. Under Section 303(d), the States must consider nonpoint sources throughout their TMDL/WLA processes, while identifying and ranking waterbodies in terms of the severity of pollution and the importance of designated uses, and when reviewing water quality standards.

EPA recognizes that nonpoint-source control programs can contribute to resolving problems in those waters where nonpoint sources, either alone or in combination with point sources, prevent the attainment of designated uses. Therefore, EPA is developing a national nonpoint source policy to assist all public and private interests in controlling nonpoint source pollution. In addition, emphasis will be concentrated on enhancing our understanding of the cause-and-effect relationships of nonpoint source pollution. One example of the special tools being developed to deal with nonpoint source problems is the Nationwide Urban Runoff Program (NURP), designed to assess the nature of urban runoff, its impacts, and the effectiveness of control activities. NURP will be discussed in more detail in Chapter 4.

Construction Grants

Given the large number of wastewater projects being considered for funding under the construction grants program, it is essential that remaining funds be allocated in a manner which most effectively ensures environmental cleanup. EPA, as part of its larger effort to assist States in water quality management activities, is issuing guidance to assist the States in focusing construction grants program funds to projects which will result in the greatest water quality and public health benefits. The importance of these benefits is stressed in the Municipal Wastewater Treatment Construction Grants Amendments of 1981. These amendments link construction grant decisions to water quality standards by requiring that after 1984, no construction grant can be awarded unless water quality standards for the water segment in question have been reviewed and revised as appropriate. EPA construction grant regulations (published interim final on May 12, 1982) are designed to implement the 1981 Amendments. They require that States establish priority systems which consider the impairment of water uses resulting from existing municipal pollutant discharges, and the extent of use restoration or public health improvement that results from the reduction in pollution.

Priority Waterbodies

The processes which translate water quality standards into permits for pollution discharges, and ensure that municipal wastewater treatment plants are built where the greatest benefits will be achieved, offer substantial potential benefits to State and local interests in the form of cost-effective, achievable pollution controls. However, it is clear that implementation of this approach will take considerable time both because of State and local resource limitations and because of the complexity of the decisionmaking process.

To ensure that water cleanup resources are efficiently managed, EPA's water pollution control effort calls for the identification of priority waterbodies. Priority waterbodies are those areas for which pollution abatement and control decisions are needed to prevent or reverse the impairment of a designated use. Factors to be considered in identifying priority waterbodies include, but are not necessarily limited to: the use to be protected, including human health; the severity of the use impairment or the severity expected if no actions are taken; and the margin of environmental benefits expected for the resources expended. Priority waterbodies need not be construed only as "dirty waters;" maintenance of high quality waters and existing water uses are as important as correcting water quality problems. Once priority waterbodies are determined, pollution control actions such as standards setting, wasteload allocations, permit issuance, and nonpoint source programs should be identified and scheduled.

In the 1982 Section 305(b) reports, thirty-nine States and territories provide some information on their waters of concern, usually including a list of specific waterbodies; no information is available for the remaining States. This information is summarized in Appendix A. The results vary considerably from State to State, in part because States use varying definitions of "streams," "segments," and "basins." Many of the States plan to refine and standardize their selection systems for priority waterbodies and are in the process of revising their listings. Nevertheless, it is clear that there are a large number of specific waterbodies which the States believe should receive priority attention. For instance, 27 States and territories which use "segments" as the unit of measure list over 1,500 segments as waters of concern. A wide range of pollutant sources—especially municipal discharges, agricultural and urban runoff, and combined sewer overflows—are reported to affect these waters. Of these sources, municipal discharges are the most commonly reported. Bacteria, dissolved oxygen, nutrients, toxic substances, and suspended solids are the constituents of highest concern in these waterbodies.

3 Water Quality Status

Waters Meeting the 1983 Clean Water Act Goal

The interim goal of the 1972 Clean Water Act states that, wherever attainable, "...water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water, be achieved by July 1, 1983." Estimates of the progress toward this goal are provided by 21 States and summarized in Table 1 below. While it is difficult to make a definitive statement concerning progress toward this goal, the data provided by States in the 1982 Section 305(b) reports indicate that the majority of waters meet the interim goal of the Clean Water Act.

Several points should be noted about this information. First, these estimates are based largely on 1981 data and thus are not the final figures on waters meeting the Clean Water Act goal. The 1984 National Water Quality Inventory will include 1983 data and hence contain a more accurate estimate of the Nation's progress toward this goal. Second, the States generally based their estimates on the degree to which their water quality standards were met. As discussed in Chapter 1, applicable State standards may involve designated uses either more or less

Table 1 Waters Meeting the 1983 Goal as Estimated in State Section 305(b) Reports

State	(A) Basis for Estimate	Percent of (A) Currently Meeting Goal	Percent of (A) Expected to Meet Goal	Primary Reason(s) for Nonattainment of Goal
Arkansas	6,239 major stream miles	Not reported	77%	Nonpoint sources
California[1]	27 major streams	85%	Not reported	Nonpoint sources, especially agricultural return flow
Connecticut	963 major river miles	70%	Not reported	Combined sewer overflows, nonpoint pollution, industrial discharges
Georgia	20,000 total stream miles	95%	Not reported	Combined sewer overflows, urban and nonpoint runoff, WWTP discharges
Kansas	62 stream segments	97% fishable, 90% swimmable	100%	Rural runoff, natural conditions
Louisiana	113 segments	Not reported	85%	Pesticides, untreated wastes
Maine	8,600 miles	90%	Not reported	Combined sewer overflow and nonpoint source pollution, also municipal discharges
Maryland	2,684 miles	90%	90%	Suspended solids, nutrients from urban runoff and agricultural runoff
Massachusetts	1,611 assessed miles	48%	Not reported	Nonpoint sources; industrial, municipal, combined sewer sources
New Hampshire	14,500 miles	96.5%	99%	Municipal and industrial waste, combined sewer overflows, untreated domestic discharges
New Mexico	3,500 miles	90%	95%	Point and nonpoint sources
North Dakota	47 segments	Not reported	100%	Natural conditions
Ohio	3,758 miles assessed (out of 43,000)	81%	81%	Point sources and urban nonpoint source runoff
Pennsylvania	12,962 miles	79%	82%	Abandoned mine discharge
Rhode Island	329 miles	66%	Not reported	Municipal and industrial sources, combined sewer overflows
South Carolina	88 segments	90%	Not reported	Not reported
Tennessee	13 basins	Not reported	46%	Point and nonpoint source pollution, surface mining
Texas	16,115 miles classified	91%	97%	Sluggish flows, municipal, industrial waste
Vermont	1,126 miles assessed	84%	100% fishable (swimmable "where attainable")	Municipal discharges, combined sewer overflows, nonpoint sources
Virginia[1]	27,240 total stream miles	95%	Not reported	Kepone from industrial discharger; mine drainage; abandoned industrial plant; nonpoint sources, especially agricultural
Washington	170 segments	About 60%[2]	Not reported	Nonpoint sources, natural conditions, point sources

[1] 1980 estimates

[2] Includes 39 upstream segments for which definitive information not yet available but which are believed to meet goal

restrictive than the fishable/swimmable goal, and may not reflect local environmental, technological, and economic constraints effectively precluding use attainment. Finally, the States have traditionally assessed their water quality by measuring the frequency with which the chemical constituents of water, such as heavy metals or ammonia, violate established standards of water quality. States are just beginning to assess water quality in terms of use impairments and to conduct biological analyses of water.

Only those States which report on the bases for their estimates of waters meeting the fishable/swimmable goal are included in Table 1; these bases vary widely among States. For example, California bases its estimate on an assessment of 27 major streams, while Georgia uses 20,000 stream miles as the basis for its estimate. Because of these varying methods of assessing goal attainment and because the number of stream miles assessed is only a small fraction of the Nation's total miles of waterways, no quantitative national conclusions should be drawn from these assessments. However, Table 1 does indicate that a majority of the Nation's waters assessed in 1982 meet the interim Clean Water Act goal. The States cite point sources, nonpoint sources, and, to a lesser extent, natural conditions as reasons for nonattainment of the 1983 goal.

State Water Quality Trends

Twenty-one of the 35 States providing overall trend information in the 1982 Section 305(b) reports cite continuing improvement in water quality. For example, New Hampshire reports that 97 miles of streams have improved in quality since the 1980 Section 305(b) report and now meet the interim goal of the Clean Water Act; Mississippi reports that at 31 of 36 trend stations, water quality has either improved or been maintained at good levels; and Wisconsin notes that improving water quality trends are now apparent in that State, particularly for total phosphorus and suspended solids.

Fourteen States report generally stable water quality trends. New Jersey, for example, reports that no significant improvement or decline in water quality is noted over the past four or five years; Arkansas states that its water quality conditions are generally good and stable; and Oregon reports that its initial trend evaluations indicate no appreciable change in water quality between 1976 and 1981.

No Statewide trends of degrading water quality were reported in 1982. However, 29 States report some degrading trends in localized areas. Georgia, for example, notes a decrease in water quality in the Satilla and Ochlocknee Rivers below certain cities. Rhode Island states that monitoring of biological organisms in that State's waters reveals some degradation at selected stations; and in California, 6 of 27 priority streams are reported to show some deterioration in 1980-1981.

It should also be emphasized that trend assessments were made by the States using a variety of methods and for different reporting periods. For example, Virginia bases its assessments on trend analysis of four conventional (i.e., non-toxic) pollutants over a period of record varying from 5 to 15 years; North Carolina reports on the reduction in number of degraded stream segments between 1980 and 1982; Wisconsin compares 1977-1978 pollutant levels to 1980-1981 levels at 44 sites across the State; Kansas reports on trend data for nine rivers gathered since 1967; and in Arkansas, trends are measured using biological monitoring data gathered at 44 sites over the past 4 to 5 years.

Additional Issues

In addition to describing water quality trends and conditions, State Section 305(b) reports provide insights into the sources of water pollution and other water quality issues of concern to States. Information concerning the three primary sources of water degradation traditionally cited by the States—point source discharges, nonpoint source pollution, and natural conditions—are described in the following chapter. Two additional water quality-related issues most commonly cited by the States—ground water pollution and toxics—are discussed below. This brief discussion serves primarily to highlight these special topics to which many States devoted considerable attention in their 1982 reports.

Ground water: Ground water contamination and/or depletion is widely reported in over half the States. Waste disposal, landfill leakage, septic tank discharges, and overdrafting are the most commonly reported causes of ground water problems. Many States report that ground water quality programs are underway to identify problem areas and manage existing supplies. For example:

- In New Mexico, 105 sites with known contamination problems have been identified, and a monitoring program has been implemented based on an inventory of major sources of potential contamination and a Statewide analysis of the vulnerability of aquifers to contamination.
- Wisconsin reports that interagency planning is underway in the State to halt further ground water contamination from irrigation and pesticide runoff.
- Oklahoma reports on the development of ground water quality monitoring programs and a permit issuance program for users of ground water resources. Several studies are being conducted to delineate ground water characteristics and help develop overall ground water standards.
- Oregon reports that it has developed ground water protection guidelines which are supplemented by special control measures in problem areas.
- Washington reports that ground water management in that State is receiving increased attention. A management plan protecting the Spokane Valley aquifer has been completed and certified, and a geohydrologic study has been undertaken for the

130 square miles of the Chamber Creek-Clover Creek aquifer.

- Connecticut reports that it has conducted a ground water inventory and administers a monitoring network of nearly 800 community water supply wells. Ground water sampling is also conducted at landfills and other potential pollution sources.

Toxic pollutants: Toxic pollutants are generally defined as substances which, by themselves or in combination with other substances, may be harmful to life. Many chemicals, when manufactured or used under appropriate conditions, present little risk of adverse impacts on human health or the environment. However, other chemicals can cause severe damage, especially if improperly handled. It is often difficult to quantify adverse impacts on humans and the environment. Gross impacts such as fish kills are obvious. More subtle effects can only be measured using aquatic organisms in acute tests (generally, where mortality is the end result) and chronic tests (generally, where sublethal effects such as impacts on reproduction and growth are the end result). Congress recognized the pervasiveness of toxic substances in the Clean Water Act when it set as national policy that the discharge of toxic pollutants in toxic amounts be prohibited.

Toxic pollutants in water, fish tissue, and bottom sediments can come from a variety of sources including industrial and municipal operations, agricultural runoff, spills, and solid waste disposal. In 1982, thirty States cite standards violations or use impairments due to toxic pollutants.

New York reports that fishing bans and consumption limits have been imposed due to chlorinated organics in Lake Ontario game fish, PCBs in Upper Hudson River fish, and mercury in Onondaga and Cranberry Lakes. A central toxics coordinating group has been established in the State and enforcement procedures strengthened to deal with the toxics problem.

Virginia reports on three toxic problem areas in the State caused by industrial manufacturing operations which have now been halted. Mercury contamination affects two sites—81 miles of the North Fork of the Holston River and 102 miles of the South River/South Fork of the Shenandoah. The pesticide kepone affects 113 miles of the James River estuary. Some evidence exists that clean sediment is burying the old contaminated sediment in the James River, and a downward trend in kepone levels in some fish species is reported.

Michigan reports on health advisories issued by the State banning the consumption of fish from portions of several rivers due to the accumulation of toxics in fish tissue. For example, in the Tittabawassee River downstream from Midland and in the Saginaw River, fish consumption bans are in effect due to the presence of dioxin (TCDD) and polybrominated biphenyls (PBBs).

Louisiana reports that pesticides such as toxaphene, DDT, dieldrin, chlordane, endrin, and lindane are a serious problem in many agricultural areas of the State. Other examples of toxics contamination around the country include PCBs in the Indiana Harbor Ship Canal; toxic hydrocarbons in the Fort Gibson reservoir in Oklahoma; and, in New England, PCB contamination of the Housatonic River and New Bedford Harbor.

Toxic pollutants also are an important issue in the Great Lakes. Michigan reports that toxic substances significantly affect water uses in the Great Lakes. Wisconsin cites a toxic substances survey conducted in the Great Lakes area in 1979/80 which showed excessive levels of PCBs in 30 percent of the fish samples tested; in 1980/81, a second survey revealed an apparent decreasing trend. The study will continue for a third year to identify sources and verify the trend information. Illinois reports that a number of toxic substances have been noted in Lake Michigan fish at levels above the U.S. Food and Drug Administration action levels; however, a decreasing trend is noted for PCBs and DDT in Lake Michigan fish. And according to the New York 1982 report, a variety of toxic pollutants including PCBs, mercury, and mirex have been detected in Lake Champlain, the St. Lawrence River, Lake Ontario, and Lake Erie. A pattern of declining PCB levels is noted for most species tested in Lake Ontario, although more testing is necessary to determine any clear trends. PCB data for Lake Erie and Lake Champlain do indicate declining levels since the mid-1970s.

Levels of toxic substances appear to be declining in some State waters due to pesticide bans and point source controls. For example, declines are reported for chlordane levels in Illinois; copper, cyanide, and mercury levels in Indiana; and PCB levels in Arkansas. The Ohio River Valley Water Sanitation Commission reports major improving trends for cyanide and lead.

It has become clear that more information is needed about toxic pollutants. Over the past five years, EPA has performed an intensive review of available information and has conducted limited amounts of sampling of waterways and effluents to better understand the toxicity, production and use, environmental fate and effects, and potential for human exposure to pollutants in U.S. waters. The results show that in many cases, well-operated and maintained biological and physical chemical waste treatment systems can remove significant amounts of these pollutants.

- Studies of industrial wastewater samples show that, although the current BPT discharge limits and existing BPT permits were aimed at controlling conventional pollutants, they are at the same time removing toxic organics and heavy metals to a significant degree. The BPT controls on 26 different industries will reduce the direct discharge loading of seven metals and cyanide between 80 and 93 percent from 1972 levels. Zinc, for instance, will be reduced 93 percent; lead, 92 percent; copper, 91 percent; and mercury, 90 percent. It is also estimated that BPT loadings of total phenols from 26 industries are 94 percent less than in 1972.

- A ten-year study of municipal wastewater treatment plants showed that plants meeting secondary treatment requirements provide incidental removal of priority pollutants—approximately 67 percent of the heavy metals; 80 percent of the total volatile organics; and 70 percent of the total acid-base-neutral organic pollutants. Individually, a reduction of 58 percent in copper, 65 percent in chromium, 38 percent in cadmium, and 65 percent in zinc is expected. Loadings of total phenols at levels of secondary treatment are estimated to be 69 percent less today than they were in 1972.

As noted earlier, EPA is currently issuing technology-based BAT effluent guidelines to control toxics from both direct and indirect (i.e., to municipal plants) dischargers. These requirements will be incorporated in permits to be implemented over the next three to four years. However, based upon EPA's Regulatory Impact Assessments and other analyses associated with effluent guidelines, it appears that even with the uniform, national technology-based controls developed by EPA, there may continue to be human ~~health and~~ aquatic life problems from some of these pollutants.

4

Pollution Sources and Control Programs

The 1982 State Section 305(b) reports indicate that both point sources of of pollution, such as municipal and industrial discharges, and nonpoint sources of pollution, such as agricultural and urban runoff, continue to cause violations of existing water quality standards in many areas of the country. Some reports, such as those from New Hampshire, Puerto Rico, and New York, cite point sources as the main causes of water pollution. Other States, such as North Dakota, Kansas, and Utah, find that nonpoint sources are more important contributors of pollution. Finally, States cite a variety of other factors (e.g., low flow and background conditions) as reasons why water segments are not meeting standards.

Point Sources of Pollution

Programs to control point sources of pollution include the construction grants program, industrial discharge controls, and controls on combined sewer overflows and confined animal feedlots. However, the States do not always attribute water quality improvements to only one point source control program. For example, five States report in 1982 that improvements in the quality of their waters are due to a combination of both municipal and industrial treatment plant upgrading and construction.

In Texas, improved municipal and industrial programs are reported to have led to better water quality despite population growth and rising levels of economic activity in the State. Pennsylvania cites improved municipal and industrial sewage treatment as the major reason for a net improvement of 136 stream miles in 1981. Georgia reports on strides made in improved water quality downstream from major metropolitan areas due to industrial and municipal controls instituted since 1970, although problems still exist in these areas. In Mississippi, significant water quality improvements are attributed to the combined effect of construction of new municipal and industrial wastewater treatment facilities, and improved operation and maintenance of existing facilities. New York reports that its water quality has improved measurably due to municipal and industrial point source controls. In the Upper Hudson River, for example, eleven problem discharges have been eliminated in recent years due to municipal and industrial plant construction and upgrading.

The construction grants program, which allocates federal funds to the States for the building and upgrading of municipal sewage treatment plants, has improved the quality of many State waters. In 1982, thirty-six States cite improvements in their waters as a direct result of construction grants. The following are some examples of water quality improvements attributed to municipal construction, as reported by the States in 1982:

- Rhode Island reports significant improvement along the Blackstone River due to completion of sewage treatment plant projects in Massachusetts and Rhode Island.
- Connecticut cites an increase in the recreational use of water and a decreased health risk directly attributed to the construction grants program.
- In Maryland, a trend toward decreasing numbers of acres closed to shellfishing has been tied to improvements in and expansion of waste treatment facilities.
- Alabama reports that construction of 66 new sewage treatment plants has resulted in improved water quality and the elimination of potential health hazards in a number of areas across the State.
- The District of Columbia reports reduced levels of certain pollutants in the Potomac River due to improved effluent quality from the Blue Plains sewage treatment plant. Restoration of the Potomac Estuary is beginning, and many sport fish have returned to the river.
- Decreases in the number of fecal coliform violations in New Mexico over the past two years are attributed to improvements in sewage treatment plants.
- In the Delaware River Basin, dissolved oxygen and fecal coliform levels are reported to have improved below Philadelphia with the completion of wastewater treatment plant (WWTP) upgrading.
- Biological surveys conducted in Illinois' Drummer Creek have revealed substantial improvement in the creek after upgrading of the Gibson City WWTP.
- California reports that construction of a new WWTP which limits its discharges to periods of high flow has been responsible for a significant restoration of water uses on the Russian River.

Some figures on recent reductions in pollutant loadings to streams are available from the 1982 reports. North Carolina notes that in the last thirty years, the amount of organic waste entering that State's WWTPs has more than doubled, yet the amount of organic waste in effluents has been halved. Alabama reports that since the implementation of the Clean Water Act, discharge of primary treated wastes in that State dropped from 65 million gallons per day (MGD) to 10 MGD, and discharge of raw sewage dropped from 2.5 to 0.15 MGD. EPA studies of municipal treatment plants show that secondary treatment plant removal of two principal conventional pollutants, biochemical oxygen demand (BOD) and suspended solids, increased 65 percent in

1980 over 1973 levels of removal. The median toxics removal rates in a sample of 20 WWTPs studied in detail range from 76 percent for metals to 70-85 percent for different types of organic chemicals.

Increases in the number of secondary WWTPs and in the total population served by secondary levels of treatment are major indicators of the success of the construction grants program. EPA studies show that increasing numbers of municipal WWTPs are achieving secondary treatment. In July 1977, 37 percent of the secondary plants required by the Clean Water Act had been constructed; as of June 1983, 69 percent had been built. Some States provide specific information on these increases. Connecticut notes that in 1970, 46 percent of its municipal WWTPs provided secondary treatment; in 1982, that figure climbed to 95 percent. Georgia reports that over 35 percent of municipal plants in that State (discharging 65 percent of total flow) received primary treatment or less in 1968. By 1981, fewer that 5 percent of Georgia's municipal treatment plants were still discharging primary treated wastes, and these accounted for only 2 percent of total flow. In Kansas, all but two WWTPs had achieved secondary treatment levels in 1982. According to the 1981 Michigan Section 305(b) report, the number of people served by secondary treatment in Michigan has risen dramatically, from 900,000 in 1967 to an anticipated 5 million in 1982.

Treatment levels in WWTPs have offset the increase in pollutant loads that have occurred because of increasing population, new sewers, and population shifts. The total amount of pollutants entering the Nation's waters from WWTPs has stayed roughly constant in the last decade, even though the population served increased by 18 million and municipal flow increased by almost 7 billion gallons per day.

The Clean Water Act provides that, if secondary treatment is not enough to protect water quality and public health, advanced levels of treatment may be required. In 1979, the Administrator was directed to review proposed advanced treatment (AT) projects to determine if AT is required and will definitely result in water quality and public health improvements. Over half of the AT projects which have been reviewed by EPA to date have been modified, or elements deferred pending further analysis, because the projects were designed using possibly too conservative water quality criteria, modeling assumptions, and/or design parameters. One result of this AT process has been the diversion of federal funds from project components likely to result in relatively small water quality improvements, to projects more likely to result in relatively large water quality improvements.

The 1982 Section 305(b) reports indicate that industrial facilities, regulated along with municipal WWTPs under NPDES permits, have steadily improved their levels of treatment and decreased their impact on the environment. According to EPA studies, the implementation of BPT regulations is estimated to have reduced industrial discharges of six key pollutants substantially from 1972 to 1977: BOD by 71 percent; suspended solids by 80 percent; oil and grease by 71 percent; dissolved solids by 52 percent; phosphate by 74 percent; and heavy metals by 78 percent. Twenty States cite improvements in water quality attributed at least in part to industrial controls. Some examples of improvements in levels of industrial pollution are as follows:

- Vermont states that the majority of its industrial facilities have achieved best practicable technology (BPT). A 1979 survey of the State's larger industries failed to uncover any serious toxic discharge problems.
- Connecticut reports that dramatic gains in water quality achieved in the late 1970s due to BPT implementation have been maintained.
- Florida reports that industrial controls have been responsible for significant improvements in Escambia Bay.
- In Mississippi, twenty industrial facilities previously out of compliance with their permits are reported to have achieved compliance within the past two years.
- Improved cyanide levels in the Ohio River mainstem are directly attributed to better industrial treatment on the Monongahela River.
- Wisconsin reports that efforts to meet 1977 BPT discharge limits in the State's 47 pulp and paper mills have resulted in a 90 percent decrease in biochemical oxygen demand and a 75 percent decrease in suspended solids discharges from these mills over the past seven years. These reductions in discharges have resulted in improved water quality in a number of areas. In the Flambeau River, for example, no dissolved oxygen (DO) permit violations have been noted since 1978 in an area which once suffered severe DO problems due to paper mill discharges.

In many States, industrial facilities are reported to have a higher rate of permit compliance than municipal facilities. New York reports that the compliance rate for industrial facilities in that State is 81 percent, while only 48 percent of municipal facilities are consistently in compliance. In Wisconsin, over 90 percent of industrial dischargers are reported to be meeting BPT requirements, while 60 percent of municipal dischargers are meeting assigned treatment levels in mid-1982. In Nebraska, 40 percent of municipal wastewater treatment plants are reported to fully comply with permit requirements, while 60 percent of industrial facilities were in compliance in 1981. Oregon reports that fewer industrial than municipal facilities are having trouble meeting permit limits.

EPA studies show that the percentage of major industrial plants in significant non-compliance with their permits decreased from 18 percent in 1981 to 15 percent by December 1982. EPA has placed major emphasis on improving the compliance rate of municipal plants; the percentage of major municipal plants in significant non-compliance with their permits decreased from 27 percent to 22 percent during the same period.

Some improvement in the treatment of combined sewer overflows has also been noted by the States. The District of Columbia reports that combined sewer overflow volume to the Potomac River was reduced by 66 to 70 percent due to simple sewer maintenance repairs. North Dakota states that most of its sites affected by combined sewer overflows are currently involved in sewer separation projects. Nevertheless, combined sewer overflow problems have not generally received the same level of control as other point sources, and in some cases are reported to cause severe degradation.

Some success in the control of runoff from confined animal feedlot operations has been reported by the States. For example, Missouri reports that its feedlot management program has significantly reduced the amount of animal waste entering Missouri streams; the waste has been recycled into crop fertilizer valued at 8.6 million dollars. North Dakota reports that its program to control runoff from animal holding or feedlot facilities has prevented a substantial amount of pollution from entering the State's waters.

Despite decreases in levels of significant industrial and municipal non-compliance and many examples of water quality successes reported as a result of point source controls, point sources of pollution continue to cause significant water degradation. For example, Puerto Rico states that high fecal coliform levels, which indicate the presence of inadequate, overloaded municipal facilities, are its worst water pollution problem; Georgia and Mississippi report that increases in population growth are causing WWTP overloads and, therefore, a need to continuously expand existing facilities; and in Illinois, bottom sediment sampling is reported to reveal a number of metals and other toxics originating from industrial and municipal operations in the Chicago area. Combined sewer overflows are reported to be a major factor in the chronic water quality problems affecting San Francisco Bay, and are reported to be one of the primary reasons for the failure of some Connecticut waters to meet standards. In Rhode Island, combined sewer overflows are reported to be a major reason for shellfish bed closures in Narragansett Bay. Another problem mentioned by the States is the possibility of future increases in water pollution due to intensive energy development projects such as synfuels production and increased oil drilling and coal mining activities.

The most commonly cited reasons for continued point source pollution problems are resource shortfalls which prevent municipal and industrial waste treatment plant construction or upgrading; improper operation and maintenance procedures, especially at small municipal WWTPs run by part-time operators; inadequate pretreatment of industrial wastes; and delays in the facility planning and construction grants process.

Vigorous programs to improve operation and maintenance of WWTPs are underway in many States. Most programs involve formal training and mandatory certification of operators, coupled with more frequent plant inspections. Many States are directing resources to priority waterbodies to better manage their construction grant funds; nevertheless, at least a quarter of the States report that some water quality program needs may be affected by scarce resources. The adverse impacts of delays in the construction grants and facility planning process should be mitigated by the 1981 amendments to the Clean Water Act, by action being taken by many States to improve permit compliance among existing municipal and industrial facilities, and by EPA's recent streamlining of the construction grants regulations. Recent progress has been made in 1982 in reissuing operating permits for municipal and industrial treatment plants. Permitting backlogs continue, however, especially for minor plants.

Nonpoint Sources of Pollution

As point sources of pollution come under control, many States are devoting increasing emphasis to nonpoint sources of pollution. Nonpoint source control programs are developed and implemented by the States, with EPA support. However, they have not been in place as long as have point source controls and their effects are more difficult to quantify. Nevertheless, a number of successes in nonpoint source abatement efforts are reported in the 1982 State Section 305(b) reports. For example:

- Connecticut reports that its nonpoint source program has provided local governments with assistance in dealing with agricultural waste management, erosion, aquifer protection, and other nonpoint source-related issues.
- In North Carolina, better cooperation on limiting sediment runoff from construction operations is reported as more people become aware of the problem and understand ways to limit the transport of sediment. Education programs are also helping reduce agricultural runoff.
- Indiana reports that its agricultural conservation program has been "extremely successful," with four thousand farms now participating in best management practices.
- In Kansas, soil conservation practices, now used on a voluntary basis on many farms throughout the State, are reported to be effective in reducing soil erosion and should result in more complete attainment of goals.
- Nebraska reports that three cost-sharing programs have greatly contributed to the reduction of stream sedimentation in the State.
- North Dakota reports that its nonpoint source program has been very successful in selected areas, especially in developing watershed controls and educational demonstration projects.
- Oregon reports that a sediment control project has demonstrated that cost sharing, loans, and technical assistance to farmers can be successful ways of ensuring the implementation of best management practices.

In general, the use of best management practices to control nonpoint sources of pollution appears to be increasing. Forty-seven States have approved agricultural nonpoint source control programs and 39 States are reported to be taking implementation actions. Sixteen States are implementing regulatory sediment and erosion control programs to control the runoff of pollutants from construction activities. Thirty-seven States have forest practices acts, varying from regulatory to non-regulatory in nature, that are used to some extent to control nonpoint source pollutants. The States are establishing priorities for nonpoint source cleanup by ranking watersheds on the basis of potential public health risks, beneficial uses, and the solvability of the problem. Educational programs and demonstration projects are widely regarded as successful by the States.

Nonpoint source pollution, however, is reported throughout the country. In about a fifth of the States, nonpoint sources are cited as the most important cause of water degradation. In addition, most States are affected to some degree by nonpoint sources; in many cases, these sources contribute significantly to the impairment of water uses. Pennsylvania, West Virginia, Tennessee, Kentucky, and the Ohio River area are reported to be severely affected by acid mine drainage and coal mine runoff. Indiana reports that fish kills due to agricultural operations such as the use of agrichemicals account for an increasing percentage of total fish kill incidents; and in Illinois, agricultural operations are said to be responsible for half of the reported fish kills. In Pennsylvania, where acid mine drainage in combination with other sources is responsible for standards violations in nearly 75 percent of those 2,744 stream miles which do not meet standards, some progress in mine drainage abatement has reportedly been made in the past few years but is expected to slow due to limited resources. Another problem mentioned by the States is the sparseness of information on the extent, causes, and effects of nonpoint source pollution. In the case of Texas, this has prevented the setting of site-specific controls in most areas of the State.

More information must yet be gathered on a number of nonpoint source issues such as the specific cause-and-effect impacts of these pollution sources on receiving waters. These impacts can be difficult to determine because nonpoint source pollutants are usually transported to receiving waters by rainfall runoff, and hence occur during periods of high stream flow. In addition, they are often attached to soil particles and may not be in a chemical form that immediately affects aquatic life.

Long term studies of waters suspected to be degraded by nonpoint sources are in progress in many areas of the country, and should provide better information on which to base abatement measures. The Nationwide Urban Runoff Program (NURP) is one such effort designed to assess the nature and impacts of urban runoff, as well as the effectiveness of various control activities. NURP results indicate that urban runoff can contribute to impairment of water uses such as shellfishing and water-based recreation. However, the potential for such use impairments has been shown to be heavily influenced by local climatology and hydrology, and by the type of waterbody receiving the urban runoff. For instance, the impact of urban runoff has been found to be greatest in small urban impoundments which receive no other influent flows, and in small sluggish streams that originate in urban areas. Various urban runoff control practices such as street sweeping and the use of detention and recharge basins are being studied to determine best possible controls.

Nonpoint sources of pollution produce significant amounts of nutrients which adversely affect many of the Nation's lakes. Eutrophication is the "aging" of waterbodies (primarily lakes and other standing waterbodies) caused by nutrient enrichment. High nutrient levels can stimulate the growth of unsightly algae and weeds which, in turn, affect fish populations and recreational water uses. Although eutrophication occurs naturally in lakes over time, man's activities have in many instances accelerated the process. For example, urban runoff and drainage from cultivated farmlands are significant sources of nutrients and sediments; municipal and industrial discharges are also often rich in nutrients such as phosphorus and nitrogen.

By 1982, many States were in the process of classifying their lakes according to trophic status (degree of eutrophication) and establishing priorities for cleanup. The following table summarizes State-reported levels of eutrophication. Most States have classified only a portion of their total number of lakes according to trophic status.

Table 2 Lake Eutrophication

State	Number of Lakes Classified	Percent of Classified Lakes which are Eutrophic
Connecticut	70	27
Iowa	107	100
Kentucky	45	64
Minnesota	500	70
Ohio	119	84
Pennsylvania	26	81
Puerto Rico	22	81
Tennessee	112	48
Virginia	161	35
Washington	123	18
Wisconsin	1,500	15

Other Factors

A variety of factors other than point or nonpoint source discharges affect the use of the Nation's waters. The most commonly reported factors include low flow or stream flow variations, dam releases, channelization and other hydrologic modifications, and natural sources of pollution. Thirty-seven States report that their waters are affected to some degree by these factors, which are widely found across all geographic areas. In a number of States, these factors are reported to cause repeated standards violations and impairment of designated uses. For example:

- The North Dakota 1982 Section 305(b) report indicates that water quality degradation in the State results from natural substances occurring in the soils; this degradation is aggravated by point and nonpoint sources. Naturally occurring sodium in the Missouri River Basin impairs irrigation uses; intermittent or low flow reduces the capacity of some streams to support fish populations; and steep stream banks, extreme flow fluctuations, and unstable, silty riverbeds naturally impair fishing and swimming uses in some rivers.

- In Massachusetts, impoundments on the Ten Mile River are reported to create conditions leading to eutrophication and sedimentation. In addition, reservoir releases which cause water level fluctuations are reported to limit populations of bottom-dwelling aquatic organisms in the Little River.

- New York reports that some streams in that State have little or no flow in the summer months due to flow regulation for navigation or power generation purposes; these "stress segments" cannot adequately dilute discharged wastes. In addition, canalization of the Mohawk River causes nutrient and sediment traps and encourages the growth of nuisance aquatic vegetation.

- New Mexico reports that water level fluctuations are the single most important factor affecting fish management in mainstem reservoirs. Hydrologic modification and diversion of stream flow are partially responsible for one stream's failure to meet standards. One aspect of normal dam operation—the release of reservoir bottom waters—is reported to be responsible for occasional dissolved oxygen and phosphorus standards violations in three streams.

- In Texas, naturally sluggish stream flow and resultant low assimilative capacities are reported to magnify the effects of point sources and therefore contribute to a majority of the State's water quality problems.

- Many States report that drought conditions experienced in 1980 and 1981 led to low flow problems and concentration of chemical pollutants in available water.

5

Costs and Benefits of Meeting the Clean Water Act Goal

In their 1982 Section 305(b) reports, most States provide some discussion of the costs and benefits of certain water pollution control programs, although few States provide actual cost/benefit analyses. A common theme of most discussions is that many of the benefits of clean water, such as aesthetic enjoyment and increased recreational use, are intangible and cannot be easily measured in dollars.

As reported by the States, some of the benefits of cleaner water include increased recreational opportunities, and hence, more tourist income and income resulting from the sale of recreational products; increased and improved commercial fishing and shellfishing; reduction in waterborne diseases; increased value of waterfront property; increased agricultural productivity through the conservation of topsoil; decreased cost of water treatment for public water supplies; and reduced influent or raw water treatment costs for industrial users.

Additional benefits have been reported to result from the construction grants program, including employment of construction personnel in the building of waste treatment plants; relocation of industries to cities that have upgraded their waste treatment facilities; doubling of crop production where spray irrigation of highly treated effluent is used; use of stabilization ponds as waterfowl production areas; and financial savings to homeowners who would otherwise maintain and operate individual septic tanks. Few of these benefits can be measured quantitatively for use in cost/benefit comparisons.

Many costs are also difficult to assess. Besides the direct cost of financing and maintaining pollution abatement facilities, indirect costs and impacts can also be weighed. These indirect costs include the possible closure of older industrial plants which are not able to afford the cost of retrofitting outmoded pollution abatement equipment in addition to other plant modernization costs, and declines in public services or increases in taxes as municipalities spend more money financing waste treatment facilities.

Despite the difficulties of calculating these costs and benefits, some States performed partial cost and benefit analyses of water pollution control programs, using best available information. Minnesota, for example, provides specific information on costs and benefits in its 1982 report. The cost of achieving the fishable/swimmable goal in the Mississippi River near Minneapolis-St. Paul was evaluated, as well as the amount citizens were willing to pay for cleanup. This area of the Mississippi is affected by water quality standard violations for dissolved oxygen, ammonia, and residual chlorine; contamination with industrial wastes such as copper, cadmium, and mercury; and combined sewer overflows (CSOs). CSOs are the primary obstacle to achieving the swimmable goal in this section of the river, and account for 98 percent of the summer loading of fecal coliform bacteria to the area.

A Minnesota CSO study concluded that the preferred solution to the problem would require a combination of new interceptors, sewer separation, storage and treatment. The estimated capital cost for such improvements was determined to be 349 million dollars, which translates into an annual charge of $41 per household in the Minneapolis-St. Paul area. A survey conducted for the Metropolitan Waste Control Commission asked area residents how willing they were to pay for fishable and swimmable water in this section of the Mississippi River; it was determined that individual households are willing to pay between $44 and $67 each per year. The benefits to local residents of improvement in water quality—estimated to range between 38 and 57 million dollars per year—are expected to increase over time as recreational demands escalate.

Kansas reports that it assessed the cost and benefit implications of water quality management programs conducted under Section 208 of the Clean Water Act. Capital, operation and maintenance, and program administration costs for three different levels of treatment—existing, intermediate, and full—were identified. Five benefit categories were also assessed: agricultural benefits; municipal benefits; industrial benefits; recreational and aesthetic benefits; and health benefits. Benefit-cost ratios were determined by comparing the present value of the total benefits to the present value of the cost to obtain those benefits. Kansas' benefit-cost assessment indicated that full levels of treatment, roughly equivalent to the concept of "zero discharge of pollutants," would not be environmentally or economically feasible. A water quality management plan incorporating elements of the intermediate levels of treatment program for agricultural runoff and mineral intrusion, with elements of the existing nonpoint source control program, was adopted by the State as a result of this analysis. The 20-year cost of this plan was estimated at 280 million dollars, with benefits to the State over this period estimated at 843 million dollars.

A third partial cost/benefit analysis, conducted as part of Missouri's water quality management plan, is reported in 1982. According to the Missouri Section 305(b) report, the expense of soil conservation measures was assessed against the savings realized from conserving topsoils and so maintaining agricultural productivity. This study found that the cost of the program was justified by a reduction in long term productivity losses only in shallow topsoil areas where loss of topsoil will become critical in 30 to 60 years. In deeper soil areas, reduced productivity losses did not balance erosion control expenditures.

The Missouri report notes that an incentive program is necessary to gain widespread farmer participation in the program, as the short term returns from such a nonpoint source pollution control program are small compared to the costs.

Cost/benefit analyses are not yet in wide enough use to permit national assessments of water pollution control programs. From the examples cited above, it is apparent that the process of assessing the benefits of clean water needs to be refined, and that more precise information on costs must still be gathered before comprehensive conclusions about the costs and benefits of the wide range of water cleanup efforts will be possible. However, despite these analytical limitations, the State Section 305(b) reports clearly show that the Nation's investment in pollution control has resulted in many highly valuable, if often intangible, benefits.

Glossary

Acute toxicity: Any toxic effect that is produced within a short period of time, usually within 24-96 hours. Although the effect most frequently considered is mortality, any harmful biological effect may be the end result of acute toxicity.

Aquifer: Water-bearing geologic formation from which drinking water supplies are often drawn.

Bioaccumulation: The process by which certain organisms remove substances, including some toxics, from their environment and store them in their tissues. The concentration of these substances increases at each higher step in the food chain.

Bioassay: A process for determining the biological effect of some substance, factor, or condition and employing living organisms or cells as the indicator.

Chronic toxicity: Toxicity marked by long duration that produces an adverse effect on organisms. The end result of chronic toxicity can be death, although the usual effects are sublethal (e.g., reduced growth, inhibited reproduction).

Combined sewer overflows: Discharges occurring when excessive rainfall is added to normal sewage flows in systems where storm and sanitary sewers are combined.

Effluent: Outflow discharged from an industrial or municipal wastewater treatment plant into a body of water such as a river or stream.

Load Allocation: The portion of a receiving water's loading capacity (defined as the greatest amount of loading that a water can receive without violating water quality standards) that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources.

Minor permittees: Municipal and industrial wastewater treatment facilities designated under an EPA priority system as having less impact on receiving waters (because of less flow, fewer toxic constituents in effluents, etc.) than other, higher priority major permittees.

Nonpoint source pollution: Diffused pollution resulting from water runoff from urban areas, construction sites, agricultural and silvicultural operations, etc.

NPDES: National Pollutant Discharge Elimination System; permit program imposing discharge limitations on point source dischargers based on national performance standards for new sources, or on water quality standards.

Point source pollution: Pollution discharged through a pipe or other discrete source from municipal wastewater treatment plants, factories, confined animal feedlots, or combined sewers.

Primary treatment: First stage in the basic treatment of sewage that removes settleable or floating material using screens and settling tanks.

Priority pollutants: Toxic pollutants designated for control under Section 307(a)(1) of the Clean Water Act because of their suspected high toxicity and persistence in the environment.

Secondary treatment: Second stage in wastewater treatment systems in which bacteria consume the organic content of wastes in trickling filters or through the activated sludge process.

Total Maximum Daily Load: The sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background.

Wasteload Allocation: The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation.

Waters of concern: Waters identified by the States as actual or potential problem areas that require management attention.

Appendix A

Waters of Concern Identified in 1982 State Section 305(b) Reports

State	State Definition and/or Methodology for Selecting Waters	Number	Source of Pollution	Parameters of Concern	Comments
Arizona	Streams cited in list of most serious WQ problems**	9 streams	Municipal dischargers, mines, feedlots, NPS pollution	Metals, nitrates, fecal coliforms, phosphorus	
Arkansas	Planning segment ranking*	39 segments	Not identified	DO, nutrients, toxics (metals)	
California	Identified by WQ data**	58 segments	Nonpoint, point	DO, nutrients, toxics, suspended solids	19 segments are WQL, 39 segments are EL
Connecticut	Identified by not meeting WQ standards**	31 segments	Combined sewer overflows, WWTP, industrial wastes	Not identified	
District of Columbia	Major tributary problems*	10 segments	Storm sewers, dumping	Not identified	
Florida	Water quality problem areas*	23 basins/segments out of 83	Municipal and industrial wastes, urban and agricultural runoff	DO, nutrients, bacteria	
Georgia	Major problem areas*	6 segments	Municipal wastes, urban runoff, sewer overflows	Bacteria, DO	
Illinois	Indicated by WQI**	20% of streams exhibit greater than moderate or severe pollution problems	Not identified	Bacteria, metals, DO	
Iowa	Identified by not meeting WQ standards**	38 segments	Point and nonpoint sources	Bacteria, ammonia	2.4% of over 10,000 observations showed standards violations
Louisiana	Identified as severely polluted**	18 segments	Agriculture, industrial and municipal wastes, urban runoff, hydrologic modification, salt water intrusion	DO, bacteria, turbidity, toxics	14 segments are EL 4 segments are WQL
Maine	Segments not meeting assigned use classifications**	7 segments	Municipal, industrial, combined sewer overflow, stormwater runoff	Solids, nutrients, DO, fecal coliforms, salinity, pH, hazardous materials, metals	
Maryland	Priority segments*	19 of about 180 segments	Municipal wastes, agriculture and urban runoff	Nutrients, suspended solids, bacteria	19 segments are WQL and have impaired uses
Massachusetts	Identified by standards violations**	169 segments	Municipal wastes, urban runoff, sewer overflows	DO, bacteria, nutrients	
Minnesota	Use impairment regarding fishable/swimmable goals**	Not identified	NPS pollution	Nutrients, suspended solids, bacteria	
Mississippi	Problem areas*	7 problem areas	Municipal wastes, agricultural runoff, industrial wastes	Bacteria, toxics, DO	
Missouri	Identified by not meeting WQ standards*	About 130 segments	Municipal wastes, agricultural, mine, and surface runoff, others	DO, deposited solids, fecal coliforms, toxics, pH, others	All segments have some water use impairment (primarily for aquatic life)
Montana	Apparent and potential problem stream segments**	32 of 216 segments	Municipal wastes, agricultural runoff, abandoned mines, other nonpoint runoff	Metals, suspended and dissolved solids, nutrients, others	Some degree of aquatic life impairment in 15 of 32 segments
Nebraska	a. Identified by beneficial use evaluation**	11 out of 13 basins	Nonpoint runoff, feedlots, municipal wastes	Bacteria	11 out of 13 basins are potentially not suited for assigned use
	b. Priority ranking of potential toxic pollutant problems**	4 out of 13 basins	Municipal and industrial wastes	Toxics (metals and organics)	
New Hampshire	Problem segments*	60 segments	Municipal wastes	DO, bacteria	
New Jersey	Priority ranking system prioritizes State watersheds*	29 segments (watersheds)	Not identified	Bacteria, nutrients, DO, toxics	All 29 segments have some water use impairment

Waters of Concern Identified in 1982 State Section 305(b) Reports (Continued)

State	State Definition and/or Methodology for Selecting Waters	Number	Source of Pollution	Parameters of Concern	Comments
New Mexico	Identified by significant standards violations**	6 of 59 segments	Municipal wastes, terrestrial runoff	DO, bacteria, nutrients	7 segments are WQL
New York	Priority basins*	6 basins out of 17, 40% of total area	Municipal and industrial wastes, combined sewer overflows, urban runoff, hazardous wastes	Bacteria, nutrients, toxics, DO, oil/hazardous substances	
North Carolina	Priority waterbodies*	5 segments	Industrial and municipal wastes, agricultural runoff	Mercury, nutrients	
Oklahoma	Identified as having problems of major severity based on chemical evaluation (frequent effects)**	30 segments	Only potential sources identified	Nutrients, suspended solids, heavy metals, toxics, dissolved solids, bacteria	
Oregon	a. Identified as streams with serious nonpoint source problems**	Certain streams within 19 basins	Erosion and sedimentation, animal wastes, agriculture	Not identified	
	b. Identified as streams with point source problems**	Certain streams within 10 basins	Municipal sources	Bacteria	
Pennsylvania	Segment priority categories (municipal grant program ranking system)*	208 segments (priority category 1)	Municipal and industrial wastes, combined sewer overflows, urban runoff, mine drainage	BOD/DO, ammonia, suspended solids, phosphorus, pH	Over 800 segments are WQL
Puerto Rico	Identified by frequency of violations of surface water quality standards**	1 region out of 4	Municipal and industrial waste, agricultural runoff	Bacteria, DO, phosphorus	One WQL segment, eleven "marginal" segments
Rhode Island	Impaired use segments*	18 segments	Municipal and industrial wastes, agricultural runoff	Bacteria, DO	16% of total stream miles have impairment of designated use
South Carolina	Statewide ranking*	53 segments	Not identified	Metals, bacteria, nutrients, DO	
Texas	Statewide ranking*	311 segments	Municipal and industrial wastes	DO, nutrients, bacteria	69 segments are WQL, 44 segments contact recreation impaired, 4 segments propagation of fish & wildlife impaired, 128 segments domestic raw water supply impaired, 19.5% of stream miles not in compliance with WQ standards
Utah	Priority segments*	21 segments	Agricultural runoff, municipal wastes, mining activities	Nutrients, bacteria, BOD, phenols, salinity, suspended solids	A severity index associated with impaired uses is given by stream segments
Vermont	Receive State focus**	124 segments	Municipal and industrial wastes, combined sewers, nonpoint sources	Bacteria, DO	45 segments are WQL, 79 segments are EL
Virgin Islands	Water pollution control priority list*	8 harbors/bays	Municipal wastes	Bacteria, turbidity	
Virginia	Toxic substance problem areas*	3 segments	Chemical manufacturers	Kepone, mercury	These segments do not meet fishable criteria
Washington	Identified as segments experiencing water quality problems excluding those due to natural or irreversible causes*	7 high priority, 26 others	Industrial site drainage, municipal wastes, sewer overflows	Bacteria, toxics	
West Virginia	Problem areas*	3 segments	Municipal and industrial wastes, mine drainage	Phenols, mercury, PCBs, acid mine drainage	
Wisconsin	Priority watershed program*	120 out of 330 watersheds	Agricultural runoff	Nutrients, suspended solids	
Wyoming	Priority segments*	40 segments	Municipal wastes, natural runoff, irrigation, agricultural runoff	Nutrients, suspended solids, bacteria	24 segments are WQL, all have impairment of designated uses

Abbreviations

NPS - Nonpoint sources
WQ - Water quality
WWTP - Wastewater treatment plant
WQI - Water quality index
WQL - Water quality limited
EL - Effluent limited
DO - Dissolved oxygen
BOD - Biochemical oxygen demand

*Specifically designated by State as problem/priority waterbodies

**Not specifically designated by State as problem/priority waterbodies, however, data indicate likely problem areas

Appendix B

Summary Excerpts of State Section 305(b) Reports

Alabama

For complete copies of the Alabama 305(b) Report, contact:

Alabama Department of Environmental Management
State Capitol
Montgomery, AL 36104

Summary

The Alabama Water Improvement Commission (AWIC) maintains a network of ambient monitoring stations to detect trends in water quality throughout the State. A total of 57 stations are maintained by the State, of which 27 belong to the Environmental Protection Agency's (EPA) national core network of stations.

During the report period (1980-1981), water quality in the majority of the State's lakes, rivers, and streams was good to excellent. A discussion and evaluation of water quality by river basin is included in this report. Also discussed are the various programs the State utilizes to gather information and to control pollution from point and nonpoint sources.

Since enactment of PL 92-500, Alabama has reduced the discharge of primarily treated waste from 65 million gallons per day (MGD) to 10 MGD. The amount of raw discharge has been reduced from 2.5 MGD to 0.15 MGD and the last raw discharge will be replaced during 1983. A total of 66 public waste treatment facilities have been constructed during the period. Construction of these waste treatment facilities has resulted in improvement in water quality and elimination of potential health hazards in a number of areas throughout the State.

The Alabama Water Improvement Commission issued or re-issued 118 NPDES permits during 1980 and 1981. Many of these permits contained schedules requiring construction of new facilities and completion of pretreatment programs. The Commission plans to issue or re-issue 120 municipal permits during 1982.

During 1980-1981, 14 municipal waste treatment facilities were completed with the assistance of federal construction grant funds. The total cost of the facilities was approximately 28 million dollars. Ten of the completed projects provided for replacement of overloaded or inadequate facilities; three provided sewer service where none previously existed; and one provided for elimination of a raw sewage discharge.

The Commission will continue to assign top priority to expediting federal grant applications for needed municipal construction. A priority list prepared by the Commission for fiscal year 1982 indicated a need of 100 million dollars for each of the next three to four years. In fiscal year 1982, 120 million dollars are needed to cover projects which are ready to proceed.

Since most industry in Alabama met the 1977 treatment levels, little water quality improvement was noted in 1980-1981 due to industry upgrading of treatment facilities. Noteworthy, however, is the fact that further industrial development and mining activity occurred during this period without a decline in water quality.

As further growth and industrial activity occurs, more frequent water quality studies and ambient monitoring will be required as more and more demand is put on the State's fixed stream capacity. This is particularly true in light of the new environmental view that maintaining water quality takes precedence over class imposition of effluent standards and on the expected emphasis on toxics control.

Alaska

For complete copies of the Alaska 305(b) Report, contact:

State of Alaska
Department of Environmental Conservation
Pouch O
Juneau, Alaska 99811

Summary

The following statements summarize the various types and sources of water pollution in Alaska today. Three primary concerns are discussed: threats to public health; damage resulting from natural resource harvesting; and nuisance problems.

Health Concerns: The first and most serious priority of Alaska's Department of Environmental Conservation (DEC) is protecting human health. Preventing such public health problems as contamination of drinking water supplies by sewage and toxic wastes, and public exposure to untreated wastes from leaking sewers or failing septic tanks, are the DEC's primary concerns.

Environmental Concerns: Environmental damage in Alaska results primarily from harvesting of natural resources rather than from discharges from pipes (point sources of pollution). Resources that are netted, trapped, dredged, sluiced, drilled, dug, felled, and otherwise harvested are then trimmed and transported out of Alaska for further refining. Environmental damage results from the remains of these activities—for example, mine tailings, sediments, drilling muds, carcasses, bark, and sawdust—as well as from construction and use of roads, docks, and airports to move these resources to markets. Erosion from poorly designed roads dump silt and mud into sensitive streams, fouling fish spawning areas. Intertidal fills create land out of water, obliterating bottom-dwelling animals and eliminating valuable feeding and refuge areas for migrating salmon fry and other species.

Nuisance Concerns: Stream beds littered with cans and debris affect water-based recreational activities in Alaska. Although litter is strictly a nuisance matter, Alaskans who were recently surveyed overwhelmingly listed it as Alaska's number one environmental problem.

Innate uncertainties are involved in predicting Alaska's future water pollution concerns. Resource harvesting and resultant environmental damages depend on market conditions. For example, mining and timber harvesting activities are largely based on the price of metals and logs. Similarly, construction of an Alaskan natural gas pipeline hinges on the price of gas. Possibilities also exist for oil spills caused by tanker accidents or oil well blow-outs.

The following table summarizes in more detail Alaska's water pollution concerns for 1983.

Scale of Problem Type of Activity	Pollution Type	Estimated Extent or Area Affected
Significant		
Subdivisions	Sewage bacteria	Hundreds of households
Placer mining	Mud, silt	600 interior streams
Timber harvesting	Bark deposits	About 150 marine sites
	Temperature	About 100 streams
Intermediate		
Seafood processing	Fish wastes	Several major harbors and several smaller harbors
Intertidal, wetland fills	Physical burial, silt from erosion	Coastal and wetland areas (about 500 developments yearly)
Streamside development	Runoff, silt	Fifty streams in ten coastal cities
Minor		
Large sewage discharges	Sewage bacteria	Four coastal cities
Pulp mills	Suspended solids	Two bays in SE Alaska
Recreational lakes	Residential sewage, silt from runoff	A dozen or more lakes
Potential		
Agriculture	Silt	None yet
Hardrock mining	Heavy metals, tailings, silt	None yet

American Samoa

For complete copies of the American Samoa 305(b) Report, contact:

Environmental Quality Commission
Office of the Governor
Pago Pago, American Samoa 96799

Summary

There are approximately 120 streams in American Samoa. The water quality of these streams is influenced largely by the prevailing weather conditions. During periods of dry weather, many of the stream flows diminish significantly; some dry up completely. Periods of heavy rains and erosion cause large increases in turbidity, suspended solids, and coliform concentrations.

There are only limited data available that establish the types and concentrations of nutrients, heavy metals, pesticides, or other toxic substances that may be present in these streams. The Environmental Quality Commission is continuing its baseline water quality survey of all public water supplies.

Water supply and wastewater collection and treatment are steadily improving. Through educational programs, the public is becoming aware of the importance of proper waste disposal practices and a safe water supply.

Past problems with the disposal of cannery sludges in landfills have been solved through a controlled ocean dumping program.

The sea surrounding these tropical islands is pristine; however, coastal zones are beginning to reflect the impact of modernization. Road construction is resulting in erosion and siltation of fragile coral reef systems along the shore.

The natural wetlands of American Samoa are of two main types: mangrove forests and coastal marsh. These wetlands are threatened by development and agricultural fill operations. Several activities to assure protection of the Territory's wetlands are planned. Included among them are careful review and enforcement of permits and projects related to development in fragile areas; publication of a coastal atlas that contains an inventory of all fragile areas; and development of specific programs to protect and restore these lowlands.

As agricultural programs are developing in American Samoa, pesticides are being more widely used. The government has set up a certification program for users which should prevent any major problems from occurring.

Ground water is the Territory's primary potable water supply source. The Tafuna-Leone plain supply is subject to salt water intrusion and is sensitive to contamination by leachate from activities above the water supply. The supply has been greatly diminished during periods of drought; however, with proper management there should be an adequate supply.

Arizona

For complete copies of the Arizona 305(b) Report, contact:

Arizona Department of Health Services
Division of Environmental Health Services
Bureau of Water Quality Control
1740 W. Adams St.
Phoenix, AZ 85007

Summary

The quality of Arizona's surface water at this writing is generally good. While new problems have been discovered since 1979, others have been resolved or are in the process of being resolved. Nonpoint sources (surface mining and recreation) need to be dealt with vigorously and systematically before major improvements will be seen. Overall, State surface water quality has neither improved nor declined since 1979.

The 1983 goal under the federal Clean Water Act promotes the attainment of water quality for the protection of aquatic life and wildlife, and for recreation. In Arizona, natural conditions preclude many in-stream uses throughout the year. Precipitation extremes cause many unregulated streams to be dry or running full with flood flows. Regulated rivers and streams are totally diverted for irrigation, municipal, and industrial water deliveries, except during flood flows. The presence of flood flows and the absence of perennial base flows in many of Arizona's watercourses prevent the use of some surface waters for uses protected under the 1983 goal.

During water years 1980-1981, several serious water quality problems were discovered in Arizona. Many current problems in the State resulted from historic activities. While overall surface water quality in the State remains good in spite of local pollution, ground water problems now threaten supplies to major metropolitan areas.

Trichloroethylene (TCE) contamination of ground water was found in Tucson and the greater Phoenix area. The Tucson situation is especially severe; the quantities of TCE in the local aquifer are large, there is potential for spread of contamination, and Tucson is currently solely dependent upon ground water for its municipal supply. Levels of TCE in some Tucson and Phoenix area wells are above levels that would pose a chronic health threat if the wells were used as drinking water supplies.

Severe nitrate contamination was detected in the San Pedro River near St. David and Palominas in surface and ground water. Municipal wells in the Phoenix area have been shut down due to high nitrate levels.

Mine wastes from historic operations release acid and heavy metals to a number of small Arizona streams, including Bitter Creek, Harshaw Creek, Lynx Creek, and Boulder Creek. Mitigation in most cases will prove difficult, preventing attainment of the 1983 goal of the Clean Water Act.

Some operating mines have taken action to clean up previous water quality problems caused by their operations. Such actions have apparently been effective in restoring stream quality. However, currently operating mines on the Pinal Creek watershed near Globe-Miami are responsible for severe pollution. Studies in the area are ongoing.

Recreation and recreation-based development have caused bacterial contamination and accelerated eutrophication of Arizona's waters. Bacterial problems are especially severe in the Pinetop-Lakeside area, and in certain low desert impoundments. Accelerated eutrophication is taking place in many small lakes in the White Mountains.

Improper sewage disposal remains a problem in Nogales and in the Cottonwood-Clarkdale area along the Verde River. Plans are being drawn to improve existing facilities in Payson and Summerhaven to alleviate problems in the American Gulch/East Verde River system and Sabino Creek, respectively.

Continuing water quality impacts from the 1979 releases of radioactive tailings water from the United Nuclear Mine near Gallup, New Mexico, remain unquantified. At last sampling, surface water in the Rio Puerco contained gross alpha activity levels in excess of State standards.

Arkansas

For complete copies of the Arkansas 305(b) Report, contact:

Arkansas Department of Pollution Control and Ecology
8001 National Drive
Little Rock, AR 72209

Summary

Of the 6,239 miles of major Arkansas streams, it is projected that 4,087 miles, or 77 percent, will meet the 1983 goal. Nonpoint source pollution causes the remaining 23 percent of stream miles to fall short of the goal.

Reasons for the goal not being attainable are discussed. Briefly, the Delta streams, including Cache River, Bayou DeView, L'Anguille River, St. Francis River, Little River, Tyronza River, Big Creek, Bayou Two Prairie, Bayou Meto, LaGrue Bayou, Bayou Bartholomew, Boeuf River, Bayou Macon, and virtually all of their tributaries cannot be expected to meet the 1983 goal due to physical manipulation of the stream environment: dredging, stream channelization, the clearing of entire watersheds for intensive agriculture, and the resulting nonpoint source pollution by silt, pesticides, nutrients, and organic material.

In these streams, mean fecal coliform levels almost invariably exceed the criteria for swimming. This is true both near sewage discharges which are amenable to control, and in areas far removed from point sources of pollution. Turbidity levels also discourage many recreational activities.

Generally speaking, the highly agricultural Delta region of Arkansas is heavily influenced by nonpoint source pollutants, especially those related to agricultural runoff, i.e., turbidity, suspended solids, and nutrients. The Ouachita River drainage is showing some degrading trends for dissolved oxygen, nutrients, and total dissolved solids. North Arkansas is showing the effects of current land changes where hardwood forests are being converted to pasturelands. These changes are increasing the levels of silts and suspended sediments being measured in surface waters. The extreme northwest region of the State is experiencing a decline in water quality due to increasing population and increased land application of animal waste. The southwest area of Arkansas still exhibits some signs of past petroleum production.

The poor conditions and degrading trends observed at some biological monitoring stations were counterbalanced by good conditions and improving trends at others. This results in assignments of fair conditions and stable trends for each of the Arkansas, White, Ouachita, Red, and St. Francis River Basins. Thus, a comprehensive examination of the forty-four biological monitoring stations currently being maintained in the State indicates that conditions are generally fair and trends are stable.

Great progress has been made in curtailing residual toxics in the environment. Some concern exists about PCBs, which are still being detected in many locations. This concern is caused, not by new sources of PCBs, but rather by the residual nature of the compound and its tendency to magnify in the environment. Chlordane, another residual compound which is being detected in fish from the Mississippi River, may prove to be a major problem. Currently, an interstate committee is being formed with Tennessee, Mississippi, Missouri, and possibly Kentucky to design a program to determine the extent of this problem.

Arkansas' most pressing water supply need is the protection of its large regional water supply lakes. A pilot study is now underway in Beaver Reservoir.

California

For complete copies of the California 305(b) Report, contact:

California State Water Resources Control Board
Division of Technical Services
Investigation/Program Development Section
Sacramento, CA 95801

Summary

Water quality conditions throughout California for the 1980 and 1981 biennial reporting period were generally good. Data summarized from Statewide stream sampling show that water quality conditions have continued to improve. Twenty of twenty-eight Priority I streams have water quality classified as good to excellent. Five streams have medium water quality and three streams are rated as poor. The Alamo, the New, and portions of the Middle Santa Ana Rivers do not meet the fishable/swimmable minimum standards established by EPA pursuant to PL 92-500. Results of toxic substances monitoring indicate that some areas have elevated concentrations of toxic pollutants in surface waters and in some coastal marine waters. Results of stream monitoring have indicated numerous short term water quality standards violations.

There are a number of localized surface water quality problems, but their solution is possible with already available best management practices. Some persistent problems such as mine drainage, surface erosion, and urban runoff do not have well defined solutions. Ground water overdraft and toxic pollutant contamination of municipal ground water supplies are problems receiving increased attention from State and local agencies.

Some of the highlighted water quality trends, problems, and accomplishments detailed in this report are summarized as follows:

- A major water resource problem facing California in the 1980s will be the balancing of water quality considerations against water delivery needs as the State's population continues to increase.
- Efforts over the last decade to correct major point source pollution and contamination problems have been very successful, although municipal wastewater treatment plants in major metropolitan areas such as Los Angeles, San Francisco, and Sacramento are not yet completed.
- Nonpoint sources of pollution are generally widespread geographically, and are difficult to identify and control. Further, they are usually the result of long-held land use practices. Typical nonpoint source problems include: ground water pumping overdraft with attendant sea-water intrusion; industrial toxic pollution; effects from agricultural waste drains, including toxic pollution; logging and roadbuilding practices; and drainage from abandoned mines.
- The 28 Priority streams assessed in this report have a combined length of nearly 4,000 stream miles and represent a cross section of water quality data reflecting approximately 80 percent of California's average annual runoff. Approximately 7 percent of these stream miles are classified as Water Quality Limited Segments (they do not meet quality standards sufficient to protect designated beneficial uses).
- A review of Water Quality Index (WQI) data indicates that the surface water quality conditions Statewide are generally improving. Most streams meet national goals. As measured by a composite WQI, the quality of surface water in California has improved from the medium to the good to excellent range during this period.
- California's Mussel Watch marine monitoring program reveals some decline in PCB levels. Mussel

Watch analyses also show evidence that chronic, low-level oil pollution may exist along the entire California coastline.

- Toxic Substances Monitoring Program activity during water year 1980-81 revealed that sample organisms from eleven sampling sites contained 28 toxicant concentrations that exceeded recommended guidelines for fish and wildlife protection. A few samples in Northern California streams have contained pollutant levels exceeding FDA guidelines for human consumption.
- Within the reporting period, several localized ground waters were found to contain high levels of industrial chemicals and pesticides. Extensive sampling, coordinated among several agencies, was designed to more closely define the sources of the contaminants, the path of ground water travel, and best corrective measures. Regional Board enforcement actions have been initiated, and cleanup and restoration have begun in several areas.

Colorado 1980

For complete copies of the 1980 Colorado 305(b) Report, contact:

Colorado Department of Health
Water Quality Control Division
4210 E. 11th Avenue
Denver, Colorado 80220

Summary

Because of its geographical location and topographical features, no significant amount of usable water flows into the State from outside its boundaries. Colorado depends on rainfall and snowmelt for all of its surface and ground water supplies.

Gross stream pollution where the water is unfit for any beneficial use is very uncommon in Colorado, except possibly in some historic metal mining districts and immediately below some natural mineral springs or seeps.

Mine drainage from inactive metal mines containing toxic metals and acidity is the most intractable water quality problem in the State. The many-faceted nature of this problem has been detailed in a report prepared by the Division for the Statewide 208 Water Quality Plan, entitled *Mining and Water Quality in the State of Colorado*(1978). Current effort in this problem area is aimed toward establishing the feasibility of rehabilitating metal mine drainages.

Natural drainage from heavily mineralized areas across the State is also a major limiting factor constraining the uses of Colorado's streams. There are many documented instances where streams have been shown to contain fish-toxic levels of heavy metals which are attributable to natural drainage.

Discharges of treated and untreated minicipal or industrial wastewater can have a significant influence on the receiving stream waters. Since point sources of pollution, for the most part, are controllable, a great deal of emphasis is placed by the Water Quality Control Division on controlling such discharges.

Colorado's discharge permit program is now fully operative, and the majority of the dischargers to State waters have been issued permits.

Major water quality impacts have been attributed to agriculture in Colorado. It is important to recognize that in general, few pollutants are actually introduced to streams by agricultural activities. The main effect of using streams for irrigation is to further concentrate water constituents or parameters already in the water. However, erosion from fields disturbed by agriculture can cause significant sedimentation in streams receiving the runoff. Most farmers use management practices that minimize erosion.

The greatest effect of agriculture upon streams in this State is the depletion of flows. Diversions can completely dry streams or leave so little water that the aquatic ecosystem is severely reduced and human recreation is impossible. Low summer flows, coupled with rising water temperatures, reduce the assimilative capacities of the streams for pollutants. Of course, municipal and industrial diversions may have the same flow-reducing effect as agriculture.

Several other important water quality impacts to streams having a more localized effect are derived from urban runoff, construction activities, and poorly executed silvicultural activities.

Connecticut

For complete copies of the Connecticut 305(b) Report, contact:

Connecticut Department of Environmental Protection
Water Compliance Unit
165 Capitol Avenue
Hartford, CT 06115

Summary

Since the passage of Connecticut's Clean Water Act in 1967 and the Federal Water Pollution Control Act Amendments of 1972, there has been a vast improvement in water quality due to an aggressive and well supported State water pollution control program. The first sources of pollution addressed were severe contamination problems such as continuous raw or poorly treated sewage discharges and industrial discharges having little or no treatment. The major thrust of the Water Quality Management program in the 1970s was to achieve consistent treatment levels for municipal and industrial wastewater based on reasonably available treatment technologies. Achieving this consistent treatment level was made possible by State and federal sewerage construction grants (approximately $303,500,000 and $473,000,000 respectively) and by the issuance of State pollution abatement orders (approximately 2,500). There have also been substantial expenditures for wastewater treatment by industry and local municipalities. As a result, there is greater recreational usage of the State's water resources, decreased health risks, improved aquatic habitats, aesthetic improvements, and generally a higher appreciation for these most important resources.

Although great progress has been made in improving the quality of the State's waters since the passage of Connecticut's Clean Water Act in 1967 and the 1972 Federal Water Pollution Control Act Amendments, attaining the dual goals of fishable-swimmable surface water quality and adequate unpolluted ground water for public consumption will require additional efforts to regulate, and in some cases eliminate, sources of pollution.

Existing Conditions

Since 1978, water quality in approximately 35 miles of rivers and streams which had previously exhibited poor water quality improved to the extent that the water quality goal was met.

Over 90% of the total miles of rivers and streams in Connecticut meet the criteria of "fishable-swimmable" water quality. Of the 963 miles of major waterways, 70% meet this goal. Water quality standards have been attained to a degree in all major river basins, as follows:

Basin	Percent of Total Stream Miles in Connecticut	Percent of Stream Miles Meeting WQ Standards
Housatonic	24	57
Thames	21	76
Connecticut	18	53
Central Coastal	13	72
Western Coastal	10	91
Farmington	9	83
Eastern Coastal	4	100
Pawcatuck	1	100

Connecticut's surface water quality problems stem primarily from combined sewer overflows, the need for municipal sewage treatment beyond secondary levels, the need for industrial waste treatment beyond BPT levels, and nonpoint source pollution. A major exception is the upper Housatonic River, where the water quality goal is not being met due to sediment contamination with PCBs which precludes eating fish from the river.

Six of Connecticut's most severely polluted rivers had an improving trend for at least one measured water quality parameter. Three other severely polluted rivers have remained the same or slightly regressed. Regression analysis also shows that the dramatic gains in water quality resulting from implementation of BPT waste treatment in the late 1970s are being maintained.

The vast majority of the State's ground water is suitable for drinking without treatment. However, there are many competing demands placed upon ground water resources for both water supply and waste disposal.

Lake water quality conditions have benefited from State management strategies and policies which prevent degradation by point source discharges. The elimination of federal funding under Section 314 of the Clean Water Act seriously reduces the ability of the State to conduct additional studies or implement recommendations for previously studied lakes. In addition to Section 314 funded activities, progress is being made in abating eutrophication of the Housatonic River impoundments (Lakes Zoar, Lillinonah, and Housatonic) by the implementation of advanced waste treatment for nutrient removal.

Delaware 1980

For complete copies of the 1980 Delaware 305(b) Report, contact:

Division of Environmental Control
Department of Natural Resources and Environmental Control
Tatnall Building, Capitol Complex
Dover, DE 19901

Summary

The State of Delaware's surface and sub-surface water resources are for the most part in good condition. Moreover, all but two segments, the Broadkill and Delaware River, are at least partially meeting the 1983 national water quality goal. However, most segments may have brief periods when critical parameters are of reduced quality. While the Broadkill River may meet the 1983 goal, the middle portion of the Delaware River will certainly require much more time to meet water quality goals set for 1983.

Since the 1978 inventory, surface waters have shown some improvement. Dissolved oxygen (DO) and fecal coliform bacteria levels have improved in most segments. The overall levels of nutrients improved in 16 of the State's 20 segments. Ten segments showed improvement in DO content. Only one segment (Leipsic River) showed a distinct deterioration of this factor. All other segments showed DO values similar to those measured in 1978 (at already acceptable levels). Only six of Delaware's streams show an indication of contamination by heavy metals, and none of these are seriously impacted on a continuous basis. The waters of Delaware Bay and adjoining ocean are of generally good to excellent quality.

A new review of the National Pollutant Discharge Elimination System files indicates that not all stream segments have experienced a decrease in pollutant loadings. However, this may be due in part to the expansion of sewer systems and the cross-basin pumping of sewage and drinking water. The Statewide total loadings of BOD_5 and total suspended solids have dropped by 67 and 59 percent, respectively, since 1975 (after cooling water flow is subtracted). Also, the total amount of wastewater flow has decreased by 15 percent since 1975.

Delaware's ground water is also in good condition. There have been no new major finds of widespread contaminated ground water. The designated surface water drinking supply streams (Christina River, White Clay, Red Clay, and the Brandywine River) are also suitable for such usage.

In summary, Delaware's streams have improved since 1978 and, with the continued and cooperative efforts of the numerous organizations and individuals involved in water quality management, this trend will likely continue.

District of Columbia

For copies of the District of Columbia 305(b) Report, contact:

D.C. Department of Environmental Services
Bureau of Air and Water Quality
5010 Overlook St. S.W.
Washington, D.C. 20032

Summary

The waters of the District of Columbia have improved considerably in the last 15 to 20 years, especially in levels of fecal coliform bacteria and dissolved oxygen. Over the past five years, improvements have been less easy to document because of wide variations in stream flow and weather conditions. This may indicate that the rate of water quality improvements has slowed relative to the large monetary expenditures of previous years. The full impact of the latest advances in wastewater treatment at the Blue Plains sewage treatment plant (STP) and reductions of combined sewer overflow discharge volumes will not be evident for several years, especially because of natural environmental fluctuations. However, careful inspection of the data, taking into consideration flow and weather conditions, does reveal improving trends between 1977 and 1981. Since the last assessment in 1980, water quality has shown improving trends based on the seven parameters evaluated in this report.

The following are some general conclusions reached in this report about water quality in the District of Columbia:

- The Potomac River has improved over the past five years, as indicated by decreased violations of fecal coliform bacteria, dissolved oxygen, and pH water quality standards, and by reduced concentrations of total Kjeldahl nitrogen and total phosphate.
- The Anacostia River, although showing improvements, still has serious problems with sediments, fecal coliform bacteria, and dissolved oxygen concentrations.
- Wetland areas are extremely limited and probably adversely affected by sedimentation and public abuse.
- Fishing in the District is improving, as indicated by the return of many species of sport fish, including bass.
- Two potential toxic problems exist in waters of the District of Columbia: lead in Rock Creek and other small tributaries, and chlorine discharges from Blue Plains STP.
- Combined sewer overflow volumes have been reduced by 66-70%. A final report on the study of further controls will be completed in the near future.
- The NPDES Program has resulted in water quality improvements; industry commitments to meet permit conditions have been promoted; and improvements in Blue Plains STP facilities and processes have occurred.
- Progress toward attaining the goal of the Clean Water Act has been made. However, improvement in the existing quality of the Potomac and other waterbodies in the District, or even simply maintenance of their current conditions, will continue to require large expenditures of funds.

Florida

For complete copies of the Florida 305(b) Report, contact:

Florida Department of Environmental Regulation
Bureau of Water Analysis
Division of Environmental Programs
2600 Blair Stone Rd.
Tallahassee, FL 32301

Summary

The primary objective of the report is to evaluate the quality of navigable waters in light of their designated uses and to assess progress toward meeting the goal of the Clean Water Act (i.e., "wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983").

In addition to the readily identifiable impacts of point sources, water quality in Florida's navigable waters is also affected by nonpoint sources such as agriculture, urban runoff, mining, silviculture, construction, and dredge/fill operations. The impacts of nonpoint sources are a significant cause of the accelerating eutrophication of many of Florida's lakes and estuaries.

Water quality in many streams or stream segments does not meet the appropriate stream standards (especially for dissolved oxygen and pH) because of natural conditions. Florida is richly endowed with many types of wetlands, and streams draining these wetlands generally have low dissolved oxygen and pH, and high color.

Sources of the data used in this report are STORET and the data from intensive surveys performed in conjunction with the development of wasteload allocations. STORET data are collected as part of the fixed station network (107 stations), miscellaneous DER stations, as well as the data from other agencies using the STORET system. Over 700 stations are used in this report to assess Florida's water quality.

In addition to analyzing the available data in terms of compliance/non-compliance with appropriate water quality standards, the State used a screening technique to make an overall assessment of water quality.

Twenty-three water quality problem areas in Florida are discussed. The sources of these problems include treated effluents from industrial processes, domestic sewage, and runoff from urban, agricultural, and mining operations.

Georgia

For complete copies of the Georgia 305(b) Report, contact:

Georgia Department of Natural Resources
Environmental Protection Division
270 Washington Street, SW
Atlanta, GA 30334

Summary

During 1980 and 1981, water quality in Georgia's streams, lakes, and estuaries was generally good.

Water quality in 95 percent of Georgia's estimated 20,000 total miles of streams was in the "good" or "excellent" range and was meeting the federal fishable/swimmable objectives. Additionally, there were other near natural streams that marginally met the fishable/swimmable objective during 1980 and 1981, but where growth and development in the future, without precaution, might obstruct progress toward the goal.

Where the Trend Monitoring Index was in the "fair" or "poor" range, problems could usually be related to municipal or industrial wastewater discharges. However, nonpoint sources of pollution such as urban area runoff can reduce the index to the "fair" or even "poor" range for limited periods of time in some areas.

Data from the State's water quality monitoring stations plus additional information from intensive surveys revealed that most of Georgia's streams met the applicable water quality criteria. Violations did occur periodically, mostly for the fecal coliform bacterial standard. During 1980 and 1981, extremely low flows in most streams resulting from severe drought caused an increase in violations, especially in the smaller streams.

Although many of the State's streams had record low flows during the period, data from most water quality monitoring stations revealed no significant changes in 1980 and 1981. A decrease in water quality was noted in the Satilla River below Waycross and in the Ochlockonee River below Moultrie and Thomasville. However, improvement was noted in the Oconee River below Milledgeville.

The major area of poorer water quality in the State continues to be the Atlanta metropolitan area. Although significant improvement has been achieved, additional efforts are needed, many of which are in progress. Additional improvement is also needed in the rivers below other population centers, especially Augusta, Macon, Valdosta, Dalton, and Rome. Each of these municipalities is in the construction grants program and is in need of additional federal funding to complete current projects.

During 1980 and 1981, construction activities resulted in the completion of 27 new publicly-owned wastewater treatment facilities and the elimination of ten inadequate facilities. There has been increased emphasis on compliance of municipal facilities with their discharge permits over this two-year period. Major permit violations are usually associated with inadequate plant budgets, poor operator training, hydraulic overloading of facilities, and inadequate solids handling capabilities. During 1980 and 1981, 24 consent orders or administrative orders were issued to municipalities for failure to comply with their discharge permit limitations.

During 1980 and 1981, extensive efforts were made to address nonpoint sources of pollution. A series of task force reports completed in 1978-1979 addressed the seven primary areas of concern (agriculture, forestry, mining, construction, hydrologic modification, salt water intrusion, and residual waste). Of greatest concern are potential problems resulting from agricultural, forestry, and urban runoff. Twenty-one streams in five physiographic regions are being investigated to determine the magnitude of their nonpoint source problems. The stream studies will continue for three years; once complete, a report will be issued which will guide the Division in future actions concerning nonpoint source water pollution abatement.

Guam

For complete copies of the Guam 305(b) Report, contact:

Guam Environmental Protection Agency
Box 2999
Agana, Guam 96910

Summary

Water quality data have now been collected systematically on Guam for four years. Analysis of the data indicates that surface water quality, both marine and fresh, is generally high, and that most areas generally meet Guam water quality standards.

The water quality of Guam's rivers generally meets the applicable standards, with some exceptions. During 1978/79, almost all rivers exceeded the established standard for phosphorus. Since then there have been only two reported phosphorus exceedences, in the upstream areas of the Geus and Ugum Rivers in 1980. The dissolved oxygen level at the downstream station on the Fonte River is consistently lower than the standard, although the level has gradually increased. The Fonte runs through a highly urbanized area, which undoubtedly accounts for the decrease in dissolved oxygen. All of Guam's rivers, whether they flow through rural or urban areas, contain coliform contamination.

In general, for both marine and river waters, no beneficial uses are being impaired due to water pollution. However, fishing and shellfishing in waters contaminated with fecal coliform bacteria may lead to health problems. The Guam Environmental Protection Agency has an active program of notifying the public of potential health threats as well as attempting to eliminate sources of contamination.

In general, the quality of Guam's drinking water has improved during the past three years. The number of times the public has had to be notified of drinking water standards violations has decreased sharply, from 26 times in 1979 to only 5 times in 1981.

There are 17 major wetlands on Guam, as identified by the U.S. Army Corps of Engineers. Most of these show some evidence of dredge and fill activities, generally associated with road construction. Several wetlands in southern Guam are used for agricultural purposes. Agana Swamp is under heavy development pressure since it is located adjacent to Guam's major commercial and governmental center.

Development in wetlands and flood hazard areas is regulated. In addition, since most large development projects on Guam receive at least partial federal funding, federal regulations on development in wetlands also apply.

Hawaii

For complete copies of the Hawaii 305(b) Report, contact:

Hawaii Department of Health
Environmental Protection and Health Services Division
P.O. Box 3378
Honolulu, HI 96801

Summary

The Hawaii 305(b) report describes the water quality of coastal areas based on the presence of significant point or nonpoint sources of pollution. A group of 15 water bodies identified as water quality priority waters are covered in the report. Included in the assessment of water quality in priority waters are the various factors contributing to the problems of water pollution, as well as the key parameters exceeding the State's standards.

Hawaii's water quality problems are related to both man-induced activities and natural factors; the extent and magnitude of these sources of pollution are described in this report. Improvement in sewage treatment and abatement of raw sewage discharge have shown effects on water quality. The rapid improvement in water quality since removal of point sources is included in the discussion of certain priority waters.

The fifteen waterbodies identified as priority waters in Hawaii are:

Kahana Bay
Kaneohe Bay
Pearl Harbor
Mamala Bay
(Honolulu Harbor, Kewalo Basin, Keehi Lagoon, and Ala Wai Canal)
Waialua-Kaiaka Bay
Nawiliwili Bay
Hanapepe Bay
Waimea Bay
Hilo Bay
Kahului Bay
South Molokai

The concept of water quality segments for mainland river basins is not applicable to Hawaii or the Pacific Islands. Because of Hawaii's unique insular environment, environmental problems and concerns are different than those experienced on the mainland.

The Hawaii water quality standards are based on a variety of factors unique to actual ecosystems in the State. The standards recognize the variety of water types and the natural variability within each system. The standards focus upon water quality as it affects ecosystem structure and dynamics.

Although the existing water quality in priority waters supports beneficial uses in general, attainment of the highest level of desired use is necessarily compromised by conflicting designated or existing uses.

The improvement of sewage treatment and abatement or removal of municipal waste sources have markedly enhanced Hawaii's water quality (including recovery of coral reef systems) and have significantly reduced public health hazards from swimming beaches.

Nonpoint sources of pollution associated with natural and man-related activities are the major contributors to water quality deterioration.

Idaho

For complete copies of the Idaho 305(b) Report, contact:

Idaho Department of Health and Welfare
Statehouse
Boise, ID 83720

Summary

Water quality conditions in Idaho vary geographically. The central and northern regions of the State are characterized by particularly high quality waters. Many areas within these regions are protected through wilderness, recreation area, or wild and scenic river designations. Geographic areas which are experiencing degradation are the southeast, the southwest, and the Palouse country of the Panhandle region.

Nonpoint source activities—specifically dryland and irrigated agriculture—account for the majority of pollution problems in the State. The extent of water quality impacts due to such activities can be illustrated by changes observed in the Snake River as it flows across the State. Water quality is good as the Snake flows into Idaho from Wyoming. As it flows west, quality progressively declines, reaching its poorest levels near the Idaho-Oregon border. The only measured "recovery" in water quality along the length of the Snake occurs below major impoundments due to settling of sediments and associated pollutants, and below the aquifer discharge of Thousand Springs at Hagerman. Although Snake River water quality is also affected by a combination of point and nonpoint sources on tributary streams, the vast amount of land in agricultural production adjacent to the main stem of the Snake is also a substantial source of water quality degradation.

The extent of point and nonpoint source pollution problems varies within each major drainage of the State. The nature and magnitude of water quality problems by basin are described in the complete report. The primary tool used in evaluating Idaho's water quality conditions is the water quality index developed by EPA Region 10. The basin discussions address water quality status, trends, the magnitude of point source versus nonpoint source impacts, and the extent of those impacts on the beneficial uses of the waters.

Illinois

For complete copies of the Illinois 305(b) Report, contact:

Illinois Environmental Protection Agency
Division of Water Pollution Control
2200 Churchill Road
Springfield, IL 62706

Summary

Analysis of ambient and lake network data for 1979 through 1981 does not indicate any significant overall change in Illinois' water quality. Approximately 20 percent of the water monitoring stations continue to exhibit severe pollution problems as determined by a water quality index. There is also no overall change in lake quality.

Of Illinois' 14 major river basins, the Big Muddy Basin exhibits the best overall stream quality based on the percent of stations with minimum or no water quality problems as determined by use of a water quality index. The Des Plaines Basin has the most severe water quality problems. Glacial lakes show the best overall trophic conditions, whereas artificial lakes (impoundments) in both the north and south display better trophic conditions than artificial lakes in south central Illinois.

Whereas localized water quality improvements have been documented in Illinois, the apparent lack of recent overall water quality improvement is not surprising. Agricultural impacts upon water quality are a significant factor, and programs to manage agricultural and urban runoff, as well as other types of nonpoint source pollution, are just beginning. Moreover, a significant number of municipal wastewater treatment projects for which design or construction has recently started remain to be completed. For example, 486 construction grants were awarded in Illinois from 1974 through May 1981, and approximately 50 percent or 224 projects are still under construction, in the bidding stage leading to award of construction, or completing design work. Given funding commensurate with needs, an overall improvement due to current pollution control efforts should be observed Statewide in a few more years.

Violation rates for certain selected parameters during 1978-1981 are summarized below.

ph- Only the Ohio Basin displayed significant pH violation rates; these ranged from 16 to 33%. The Kaskaskia Basin had 7% pH violation rates in 1978; all other basins had less than 4% violations.

Ammonia- Most basins were consistently below the 20% violation rate, except the Des Plaines Basin. There was an apparent downward tendency in the number of ammonia violations in the Des Plaines Basin from 1978-1981.

Dissolved Oxygen- Many basins had violation rates below 10%, and nearly all were below 20%. The highest percentage violations were found in the Big Muddy and Mississippi South Basin, with 24% and 23% respectively.

Fecal Coliform- Fecal coliform violations ranged between 40 and 80%. The Des Plaines and Mississippi South Basins had the highest rates, but were showing general downward trends. The Ohio and Big Muddy Basins had the lowest violation rates.

Iron- Apparent slight downward trends were seen in many basins. The violation rate was generally between 40 and 80%, which was not surprising because Illinois waters are naturally high in iron. The Ohio and Mississippi South Basins had the highest percent of violations.

The Ohio Basin also had some violations of cadmium, fluoride, and zinc which were not present in the rest of the basins. Mining activities in the southern part of the State may contribute to higher violation rates for several parameters, including pH, sulfate, and manganese.

The greatest percentage of violations were of fecal coliform and iron standards; some apparent downward trends were seen in some basins.

All available fish tissue data from 1980 and 1981 have been evaluated for excursions above U.S. Food and Drug Administration (FDA) action levels for contaminants in fish. The only excursions other than dieldrin and chlordane were two DDT excursions in Lake Michigan trout. Statewide excursions for dieldrin and chlordane were 2 percent and 18 percent of samples, respectively. A notable number of chlordane excursions (over 30 percent) appear in lake fish samples from the Sangamon Basin and stream fish samples from the Wabash Basin.

Lake Michigan is monitored under the terms of a cooperative agreement between the Illinois Environmental Protection Agency and the city of Chicago. The bacteriological and chemical data collected during 1980 and 1981, when compared to data of the previous 10 years, illustrate an overall improvement in water quality for the southwestern portion of the lake.

Indiana

For complete copies of the Indiana 305(b) Report, contact:

Planning Section
Division of Water Pollution Control
Indiana State Board of Health
1330 West Michigan Street
Indianapolis, IN 46206

Summary

This report assesses water quality by drainage basin. Data from each Fixed Water Quality Monitoring Station along the main stem of primary streams were compiled to demonstrate the aggregate improvement or degradation of each stream.

The following is a general summary of water quality by basin.

Lake Michigan Basin

Generally, the water quality of Lake Michigan is in compliance with applicable water quality standards. Most inland rivers and streams support designated uses, but in some instances, such as within the Grand Calumet River, the influx of toxic waste material significantly reduces the stream's capacity to attain acceptable water quality.

Maumee River Basin

Each major river within the Maumee Basin complies with State water quality standards for fish and aquatic life with respect to dissolved oxygen. Some other parameters may have concentrations detrimental to aquatic life. High concentrations of copper, cyanide, and mercury have in the past been limiting factors within this area. Recent improvement has been demonstrated. In at least two streams, partial-body contact recreation criteria are met. Standards for whole-body contact recreation are not always met in the St. Joseph River.

Wabash River Basin

The water quality of the Wabash River can generally be described as meeting the State's water quality standards. Dissolved oxygen concentrations are high enough to maintain a well-balanced fish community in most areas of the waterway. Urban discharges within the upper Basin areas sometimes create slight downstream dissolved oxygen sags. The impact of this pollution is not severe enough to inhibit stream recovery. The bacterial quality improves downstream.

Tributary streams generally comply with water quality standards. The most severely impacted stream within the Wabash River Basin is Wildcat Creek. As a result of discharges from the City of Kokomo, Wildcat Creek shows increases in concentrations of some toxic parameters. Completion of the City's upgraded wastewater collection system should result in extensive water quality improvement in the stream.

Kankakee River Basin

The water quality of the Kankakee River is good. The river is an excellent habitat for wildlife, fish, and other aquatic life and is a superior recreational resource. In the past, the only water quality limiting factor within this stream has been an unidentified source of mercury near its headwaters. The extent of this concentration was not severe enough to cause toxic problems. Data for 1979 and 1980 do not indicate that a mercury problem still exists.

Whitewater River Basin

Both branches of the Whitewater River support a diversity of fish and other aquatic life. Dissolved oxygen concentrations fell below minimum levels only once in the West Fork of the Whitewater River from 1974 to 1980. No chemical constituent concentrations were recorded that were toxic to fish and aquatic life. The bacterial quality is better in the East Fork than in the West Fork. The West Fork of the Whitewater River does not regularly comply with the bacteriological standards for recreational waters.

East Fork White River Basin

Data since 1974 indicate that the water quality of the East Fork White River continues to improve. Sufficient dissolved oxygen is present to support a diverse aquatic community. Several factors create localized pollution problems, but these local problems are being resolved.

West Fork White River Basin

The general water quality of the West Fork White River is good except for certain reaches downstream of the metropolitan areas of Muncie, Anderson, and Indianapolis. Discharges at Indianapolis affect water quality to some extent as far downstream as Spencer. A notable decrease in dissolved oxygen concentrations and a corresponding increase of coliform bacteria occur downstream from each of these municipalities. Concentrations of phenols and mercury still indicate water quality problems in some areas of the West Fork of White River.

St. Joseph River Basin

The St. Joseph River has been designated for two different instream uses: aquatic life and recreation. Dissolved oxygen concentrations are adequate to maintain fish and aquatic life. The once-high cyanide levels have been reduced during this survey period. The St. Joseph River does have problems maintaining desirable bacterial levels for full recreational benefits from April through October, inclusive. During the remaining months, when standards for partial-body contact recreation apply, bacterial concentrations demonstrate better instream compliance.

The major tributary stream, the Elkhart River, also maintains sufficient water quality for fish and aquatic life. As in the St. Joseph River, coliform bacteria concentrations periodically rise above State limitations.

Iowa

For complete copies of the Iowa 305(b) Report*, contact:

Iowa Department of Environmental Quality
Henry A. Wallace Building
Des Moines, IA 50319

Summary

The status of water quality in 1979 and 1980 was determined by evaluating water quality impacts and violations of Iowa's water quality standards. When possible, 1979 and 1980 data were added to existing long term water quality information to determine trends. Sources of pollution and pollution abatement activities were considered in attempting to correlate water quality with factors influencing it. Fish kills, spills, and accidental discharges that threatened water quality were also documented.

Statewide, the water quality of 74 streams, 107 lakes, and four major reservoirs was evaluated. Thirty-seven of the rivers were found to have water quality problems at one or more locations. Forty-nine problem areas were identified. The probable cause of the problem was identified at 25 locations. Point source discharges are thought to be responsible for water quality problems at 22 locations. Fifteen of these point sources have received construction grants funds to improve their wastewater treatment facilities. Three other point sources are undergoing remedial action of some kind. Forty-two streams and four reservoirs were identified that had no water quality problems and/or showed improvements at one or more locations. Of the 10,651 observations made at stream and reservoir locations, only 2.4%, or 255 values, violated applicable Iowa Water Quality Standards to protect the stream's beneficial use.

Trend analysis was performed at 41 locations. At 16 locations, concentrations of both BOD and ammonia remained stable for five or more years. Increasing trends in ammonia concentrations were observed at three locations and decreasing trends were found at eight locations. Increasing trends in BOD concentrations were found at two locations and decreasing levels of BOD were observed at 15 locations. On 13 of 14 streams where biological data were collected, the results showed healthy diversities of aquatic life. Evaluations of discharge monitoring data showed that 68 wastewater treatment facilities were consistently in violation of their permit limitations and thus posed a substantial threat to water quality. Twenty-four fish kills were investigated and 38 spills or accidents threatened surface waters during the reporting period.

Lake monitoring showed that all studied lakes were eutrophic. Forty-two percent exhibited thermal stratification resulting in low dissolved oxygen levels at lake bottom. Twenty percent of the lakes had one or more surface locations that exceeded the pH limits identified in the water quality standards.

Agricultural cropland is a major source of pollutants to Iowa's surface waters. Sediments, pesticides, and nutrients all enter surface water as diffuse sources during runoff periods. The contribution of sediments causes two types of problems: pollution caused by the particulate matter itself, and pollution resulting from contaminants adsorbed onto the sediment particles. Soil-attached pollutants include phosphorus, heavy metals, and many pesticides. Other pollutants are transported dissolved in the runoff. Nitrogen and some pesticides are delivered to the surface water in the soluble state.

The quality of ground water in Iowa's surface deposits is generally acceptable. While a few problems are highly localized, other problems such as nitrate levels and loss of artesian pressure have been identified over large geographic areas of the State.

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*Available from the Iowa Department of Environmental Quality for $20.50 or from the National Technical Information Service (PB83I-00214) for $19.00

Kansas

For complete copies of the Kansas 305(b) Report, contact:

Kansas Department of Health and Environment
Division of Environment
Forbes Field
Topeka, KS 66620

Summary

Major rivers in Kansas display the following characteristics: turbidity, moderate mineralization, good buffering, good oxygen characteristics, low organic loading, high nutrient levels, and high bacterial levels. Water quality trends since 1967 for nine major Kansas rivers indicate that 68 key parametric averages have shown water quality improvement or no significant change, and 22 key parametric averages have shown water quality deterioration. Water quality in Kansas streams in the last two decades has been primarily influenced by nonpoint sources, point source contributions having had their greatest impact during the period of the 1930s through the 1950s. At present, instream quality is determined almost entirely by flow regime. During low flow periods, the most significant quality influence is mineral inflow from natural sources. During high flow periods, most Kansas surface waters display their poorest quality, with significant increases in BOD, nutrients, fecal coliform bacteria, and turbidity from nonpoint source contributions.

Monitoring programs for toxic substances in Kansas have accelerated in recent years due to increased concern over these substances in our waters. Except for iron and manganese which are common in major streams, no significant concentrations of heavy metals have been found in major Kansas streams or lakes. Iron, zinc, copper, and lead are found to varying degrees in small tributary southeastern Kansas streams which drain the coal and ore mining areas. No significant concentrations occur in mainstem streams. No significant concentrations of pesticides have been found in Kansas streams at standard detection levels during normal surveillance, nor during special studies of irrigation return flow.

Biological quality in Kansas is monitored through two programs: the stream biological network with 47 sampling stations, and the lake network at 65 major lakes. Accounts of the organisms collected at biological sampling network stations and river basin survey stations over the five years of program operation indicate that virtually all streams and rivers in Kansas support adequate populations of stream-dwelling organisms. Limiting factors in streams are usually unsuitable substrate or velocity patterns.

Water quality problems associated with advanced eutrophication are not common in Kansas lakes. Excessive growths of aquatic macrophytes are restricted to a few small lakes; algae blooms and oxygen depletion, when they occur, are ephemeral conditions lasting only several days in most cases. The major water quality characteristic of Kansas lakes appears to be generally high levels of inorganic turbidity due to periodic high suspended silt loads.

Achievement of 1983 Water Quality Goals

It is currently felt that the 1983 national water quality goals of bio-support and recreation in and on the water cannot be fully achieved in all Kansas waters. However, impounded waters, lakes, and reservoirs which have sufficiently long flow-through time to allow sedimentation of suspended solids and natural biological activity are capable of full achievement of the goals. All Class A waters in the State are currently meeting full bio-support and body contact recreation requirements.

By 1983, all streams and rivers in the State should be marginally suitable, from a quality standpoint, for body contact requirements. Bacterial levels should be low during low streamflow periods, but it is anticipated that runoff will cause body contact standards to be exceeded 30 to 60 percent of the time. Beyond considerations of water quality, many Kansas streams generally are not suitable for body contact recreation because of wide, shallow channel geometry and hazardous flow patterns. Because of the above factors, the attainable 1983 water quality goals for streams are currently interpreted as bio-support and secondary contact recreation. Sixty and 56 segments, respectively, are currently meeting these goals, and all 62 segments are expected to meet the goals by 1983.

Kentucky

For complete copies of the Kentucky 305(b) Report, contact:

Kentucky Department for Environmental Protection
Division of Water
18 Reilly Road
Fort Boone Plaza
Frankfort, KY 40601

Summary

The primary activities affecting water quality in Kentucky are surface coal mining, oil and gas operations, agriculture, and domestic waste discharges.

The parameters that violate standards most frequently are fecal coliform bacteria, iron, manganese, and lead. Other parameters that show occasional violations are mercury, chromium, and cadmium. These violations occur randomly throughout the State with no discernible trends. Chronic pH violations are associated with streams affected by acid mine drainage, most notably in the Tradewater River and Green River basins. The Green River basin has the greatest number of miles of streams affected by acid mine drainage (271 miles), while the Tradewater River basin has the greatest percentage affected (79%). Data on organic chemicals in the Commonwealth's waters are very limited at this time.

Fish kills are reported by the Kentucky Department of Fish and Wildlife Resources. During the 1980-81 reporting period, 50 fish kills affecting a total of 127 stream miles were investigated.

Biological integrity was monitored at seven stations in four river basins. Conditions are reported as good at two stations, fair at three stations, and poor at two stations. The ratings are based on periphyton, macroinvertebrate, and fish community structure; stream physical habitat conditions; and water quality. Additional information is reported on fish tissue levels of toxic materials. Four stations had levels of chlordane in fish tissue which exceeded the FDA action level for this pesticide.

Under Section 314 of the Clean Water Act, a lake classification study has been conducted to assess the general condition of lakes in the State. Forty-five lakes have been classified to date. Of the 353,353 total surface acres presently classified, 74,204 acres are eutrophic, 233,213 acres are mesotrophic, and 45,936 are oligotrophic. There is documentation of impaired uses in ten lakes. Symptoms of eutrophication include excessive algal blooms, extreme oxygen depletion, excessive aquatic weed growth, turbid water, elevated iron and manganese levels, and taste and odor problems.

The severity of generalized impacts on wetlands and the extent of wetland loss is unknown. The major threat to Kentucky's wetlands appears to be their destruction due to competing land use activities and poor land management practices.

While ground water does not provide a large portion of the total water withdrawn in the State, it is an extremely important local and regional resource because it is most often used in areas where surface supplies are not physically or economically available. Approximately one-third of Kentucky's rural population still relies on private wells for domestic or household supply.

A number of earlier studies have pointed out existing ground water quality problems in the Commonwealth. The failure of on-site wastewater disposal systems (especially septic tanks and tile fields) probably represents the major source of ground water quality degradation. Other known causes of ground water contamination include waste landfills, surface disposal lagoons, oil and gas drilling and reinjection, diminished aquifer recharge, and nonpoint source pollution.

In 1981, the Division of Water initiated a comprehensive Statewide stream use classification and regulatory designation program. Where current criteria are found to be inappropriate, site-specific criteria will be recommended for approval by the State, EPA, and the public through the State's public hearing process. This effort will contribute to the mandatory triennial review and revision of the State's water quality standards, and will provide a basis for future permitting, compliance assurance, and enforcement decisions. The ultimate product will be the promulgation of surface water use designations and associated criteria for the entire State.

Louisiana

For complete copies of the Louisiana 305(b) Report, contact:

Louisiana Department of Natural Resources
Division of Water Pollution Control
P.O. Box 44066
Baton Rouge, LA 70804

Summary

This sixth 305(b) report on water quality will serve as a continuing review process to monitor, evaluate, and improve where possible the current water quality conditions of Louisiana's waters.

Information used in this report also represents intensive survey efforts and water quality reports prepared by or for the staff. A water quality index is utilized which provides a means of measuring and comparing water quality status throughout the State with respect to fishable/swimmable federal water quality goals.

General Conditions

Ninety-two of Louisiana's 113 stream segments are effluent limited and the remaining 21 segments are water quality limited. Eighteen segments within the State are in the severely polluted category and do not meet federal water quality goals.

Louisiana's water supplies—both ground water and surface water—are among the most bountiful in the Nation, but localized problems exist with salt water instrusion, residual salt accumulation, petrochemical contamination, and other industrial and human wastes contamination. Many problems that arise outside the boundaries of the State are compounded by the large volumes of water that flow to the Gulf of Mexico. Water tables tend to be shallow and aquifers are numerous. The Louisiana Department of Public Works maintains information on producing water wells.

Oxbow lakes, small freshwater lakes, coastal lakes, and impoundments are common features within the State of Louisiana. Generally these waters are moderately hard and highly productive. Cultural eutrophication of these waters is a serious problem affecting the biota; the major nutrient additions come from runoff and municipal wastes.

One area of concern in Louisiana is toxic pollution caused by agricultural activities. Pesticide pollution is one of the more serious problems in agricultural areas of the State. Persistent substances such as toxaphene, DDT, dieldrin, chlordane, endrin, and lindane continue to be both health and pollution problems near many agricultural and urban centers.

Maine

For complete copies of the Maine 305(b) Report, contact:

Department of Environmental Protection
Bureau of Water Quality Control
Division of Environmental Evaluation and Lake Studies
State House
Augusta, ME 04330

Summary

Over the past ten years, with assistance from federal and local governments and with the active concern of its citizenry, the State of Maine has succeeded in reversing a long period of decline in the quality of its waters.

Maine's waters are now much cleaner than they were just a few years ago. Some of the State's most polluted lakes have shown marked improvement. Atlantic salmon and other fish have returned to several Maine rivers. People are beginning to use many previously polluted streams and rivers for swimming, fishing, and canoeing.

Despite these improvements, a great deal more work remains to be done not only to make further progress, but also to maintain the gains made thus far. As the more severe municipal and industrial pollution sources have been abated, other previously ignored types of pollution have become more prominent. Nonpoint sources continue to degrade the quality of many of Maine's waters. Acid rain and hazardous wastes, practically unknown ten years ago, menace Maine's surface and ground waters. These "newer" forms of pollution are more insidious in their effect and are more difficult to treat than the industrial and municipal wastewaters by which they had previously been overshadowed.

Existing Conditions

The water quality of Maine's rivers and streams has continued to improve over the past two years, although not at the dramatic rate that prevailed over the preceding fifteen years. The reason for the apparent slower rate of improvement is two fold. First, the major municipal and industrial discharges are receiving the equivalent of secondary treatment and thus most of the major pollution problems have been abated. Second, the recent reductions in the availability of federal construction grant program funds have slowed the rate at which the remaining municipal treatment needs can be met.

The water quality problem areas that remain are, for the most part, segments that are affected by combined sewer overflows from the State's older urban areas and by agricultural runoff and other nonpoint source pollution. There also exist several water quality limited segments that are receiving discharge loadings which, even after receiving treatment equivalent to the technology-based standards specified in the Clean Water Act, exceed the segments' capacity to assimilate the waste. Wasteload allocation studies are being performed for these rivers on a priority basis.

In addition, the following issues are also of current concern in Maine: acid rain in lakes and streams; hydropower development; the effects of hazardous wastes on ground water; lake eutrophication; and protection of high quality waters.

The percentage of the State's river and stream miles that are currently meeting the 1983 goal of swimmable-fishable water varies depending upon the estimate of river and stream miles that is used. Previous Maine 305(b) Water Quality Status Reports have used a figure of 3,080 miles of major rivers and streams; recent information from EPA's River Reach File indicates that there are approximately 8,600 miles of major rivers and streams in the State; and the Maine Department of Inland Fisheries and Wildlife estimates that there are approximately 32,000 miles of permanent rivers and streams in the State. These three estimates of river and stream miles yield estimates of 75, 90, and 97, respectively, for the approximate percentage of waters meeting the 1983 goal.

There are seven water quality limited segments in five of Maine's eight major river basin planning areas. These water quality segments include the main stem of the Sebasticook River from the Irving Tanning Company outfall to the confluence with the Kennebec River, and the East Branch of the Sebasticook River from Dexter Village to the confluence with the Sebasticook main stem, both in the Kennebec Basin; the Presumpscot River from Westbrook to the confluence with the Atlantic Ocean in the Presumpscot-Cumberland Basin; the St. Croix River from the Georgia Pacific Company outfall to head of tide in Calais in the St. Croix Basin; the Aroostook River from the confluence of Presque Isle Stream to the Canadian border, in the St. John Basin; and the Mousam River from the Sanford Sewage District to head of tide and Goosefare Brook from the Maremont Company outfall in Saco to head of tide, both in the Southern Maine Basin.

Some river and stream segments in Maine do not meet the 1983 goal and are not expected to do so, in large part because of combined sewer overflows and nonpoint sources. These failures to meet the goal are temporary in nature, usually associated with storm events resulting in levels of fecal coliform bacteria that exceed the standard for swimming. Because of the extraordinarily high cost of correcting these problems, the temporary nature of the impact they have, and their low priority relative to other water quality problems in the State, these problems will probably not be addressed in the near future.

Maryland

For complete copies of the Maryland 305(b) Report, contact:

Maryland Department of Health and Mental Hygiene
Office of Environmental Programs
201 West Preston Street
Baltimore, MD 21201

Summary

Overall, Maryland's waters are judged to be generally of good quality. Water quality has generally remained stable, even though many problems still exist. Maryland identifies its foremost problem to be the increasing accumulation of nutrients in tidal waters and impoundments. Additional problems include pockets of dissolved oxygen depletion still remaining in site-specific, historically documented problem areas (most now targeted for correction), and extremely difficult-to-solve, long term abandoned acid mine drainage conditions in the far western portion of the State. Of lesser severity, but still deserving continuing attention, are elevated bacteriological densities that are the result of local conditions found throughout the entire State. The continuing severe diminuation of highly prized anadromous fish species and the almost total loss of submerged aquatic vegetation are other problems which have yet to be solved.

However, some accomplishments have been made. Almost all the point source discharges have achieved, or will soon achieve, levels of treatment determined to assure acceptable water quality. Many of these facilities, like Back River, Aberdeen, Sod Run, Blue Plains, and the Northeast Plant, have incorporated into their treatment processes advanced levels of treatment. Many facilities will stabilize the oxygen demanding material prior to discharge and a number will be removing phosphorus, a key stimulator of algal growth. Some evidence of these improvements can already be seen. Already the tidal Potomac—described as a cesspool of filth in the 1950s—is showing dramatic improvement. Other nutrient enriched areas like the Upper Chesapeake Bay and the Patuxent River have strategies in place to address this problem and are expected to respond in similar fashion.

A great deal has been done in Maryland to assess and control the impacts of point source discharges. The more difficult and subtle area of nonpoint source assessment and control must now be confronted in the 1980s. Nutrient (nitrogen and phosphorus) enrichment and suspended sediment generation are two of the more important areas that will have to be addressed.

The biological integrity of Maryland's waters was evaluated. The evaluation of the benthos populations (population and diversity of bottom dwelling organisms) concluded that Maryland's waters are maintaining generally good biological quality.

As indicated in the table below, less than 10 percent of the waters of the State are violating water quality standards. Of this 10 percent, approximately 3 percent is due to long term mine drainage and approximately 2 percent is related to shellfish water closures where no harvestable bottoms exist.

Summary Description of Sub-Basins

Description	Total Main Stem Miles	Miles Now Generally Meeting State WQ Standards
Chesapeake Bay Area	118	118
Ocean/Coastal Basin	81	75
Pocomoke River Basin	162	115
Nanticoke/Wicomico	156	138
Choptank River Basin	123	111
Chester River Basin	162	124
Elk River Basin	137	136
Lower Susquehanna	83	82
Bush River Basin	69	69
Gunpowder River Basin	102	102
Patapsco River Basin	132	112
West Chesapeake Basin	97	75
Patuxent River Basin	187	175
Lower Potomac Basin	249	242
Washington Metro Area	165	165
Middle Potomac Basin	136	135.5
Upper Potomac Basin	271	271
North Branch Potomac	180	97
Youghiogheny Basin	94	82.5
TOTALS	2,684	2,425

Although there are numerous shellfish closures throughout the tidal areas of the State, the general trend since 1972 has been toward a sharp reduction of closed harvesting waters. In recent years, this trend has been leveling off; between 5 and 6 percent of shellfish waters are generally closed.

The reduction of closed harvesting areas since 1972 is generally attributed to a management strategy which identifies and eliminates potential pollution sources during the design and construction phases of abatement, to improvements in and expansion of existing waste water treatment facilities under the Clean Water Act, and to improvement in Maryland's Shellfish Sanitation Program.

Massachusetts

For complete copies of the Massachusetts 305(b) Report, contact:

Commonwealth of Massachusetts
Department of Environmental Quality Engineering
Division of Water Pollution Control
Westborough, MA

Summary

The quality of the surface water of the Commonwealth of Massachusetts continues to improve significantly as 48 percent of the total river miles assessed in this 1982 report met their designated water quality classification. For comparison, the 1977 Section 305(b) Report indicated that 32 percent of the river miles assessed met their designated classification and only 26 percent exhibited Class B (fishable/swimmable) water quality. These figures demonstrate the substantial improvements which have occurred within the past five years and amplify the benefits gained from the extensive water pollution control programs of the Commonwealth.

The evaluation of the lakes and ponds of the Commonwealth has accelerated within the past few years. To date, 350 lakes and ponds have been sampled and subsequently classified according to their trophic state. A diagnostic/feasibility program has been implemented which has culminated in several restoration projects.

Over the past decade, approximately one billion dollars have been expended through the construction grants process for the design and construction of wastewater collection and treatment systems. The funding for these projects has been provided by the United States Environmental Protection Agency, the Commonwealth of Massachusetts, and individual cities and towns. This program is responsible for major water quality improvements in many waters of the Commonwealth including the Merrimack, Chicopee, Westfield, Connecticut, Millers, and Charles Rivers. This improvement is expected to continue in the upcoming decade as the sources of water pollution are increasingly brought under control.

The future water quality programs of the Department of Environmental Quality Engineering will focus upon improving water quality conditions in critical areas and will include: construction of water pollution abatement projects within the limitation of available funding; implementation of the most practical control on combined sewer overflows; evaluation of nutrient removal requirements necessary to retard eutrophication; and assessment of the effects of toxic substances upon ambient water quality and indigenous biota.

As the water pollution abatement program continues to improve the surface waters of Massachusetts, more attention will be given to the evaluation of both the quantity and quality of ground water throughout the Commonwealth. Recent discoveries of contaminated public water supply wells in a number of muncipalities in Massachusetts has clearly shown that aquifers are not immune from pollution problems such as contamination by industrial wastes and salt water intrusion. A high priority of the Department in the future is to protect the quality of ground water.

Michigan 1981

For complete copies of the 1981 Michigan 305(b) Report, contact:

Michigan Department of Natural Resources
Bureau of Environmental Protection
Environmental Services Division
Stevens T. Mason Bldg.
Lansing, MI 48926

Summary

Overall, water quality in Michigan is good. However, there are water quality problems which need attention.

The control of toxic and hazardous materials is clearly the most pressing issue in environmental protection today. Health advisories concerning the consumption of fish from certain waters in Michigan remain in effect. During 1980, Michigan implemented the Hazardous Waste Management Act, for which administrative rules were adopted in April of 1981. This law represents a significant step towards a "cradle-to-grave" toxic and hazardous waste management program.

Fish consumption warnings remain in effect for all the Great Lakes waters within Michigan's political boundaries, Lake St. Clair, the St. Clair River, and the Detroit River. Fish consumption bans remain in effect on portions or all of seven streams in the State: the South Branch of the Shiawassee River; Portage Creek; the Kalamazoo River; the Chippewa River; the Pine River; the Tittabawassee River; and the Saginaw River.

In December of 1979, the DNR identified sites where there is known, suspected, or potential ground water contamination. With help from State agencies and interested citizen groups, the DNR is developing ways to approach the investigation and cleanup of these ground waters. In 1980, ground water rules were adopted to allow more consistent and complete regulation of Michigan's ground water quality. In 1980, federal "Superfund" legislation was also enacted to provide money for identifying, investigating, and cleaning up contaminated sites.

Eutrophication of the Great Lakes has been a water quality problem for over two decades. Significant program efforts have resulted in a decrease in the amount of nutrients discharged to surface waters. As a result, significant water quality improvements have been documented in both Saginaw Bay and Lake Erie.

Significant destruction of wetlands has occurred in Michigan. In December of 1979, Michigan signed into law the Wetlands Protection Act. This Act provides for the preservation, management, protection, and use of wetlands; requires permits to alter some wetlands; and prescribes remedies and penalties.

Precipitation in the Great Lakes Basin has become more acidic in the past 30 years, largely as a result of fossil fuel combustion. To date, no adverse effects of acid precipitation have been found in Michigan's surface waters.

Minnesota

For complete copies of the Minnesota 305(b) Report, contact:

Division of Water Quality
Minnesota Pollution Control Agency
1935 West Country Rd. B-2
Roseville, MN 55113

Summary

During water years 1980-81, the overall quality of water in Minnesota was good and had improved over past years. The quality ranged from excellent in the Lake Superior Basin to somewhat impaired in the Minnesota River Basin, where high nutrient, suspended solids, and fecal coliform levels interfered with achievement of the fishable-swimmable goal of the Clean Water Act.

Field evaluations were performed on 400 waterways, and 208 of these waterways were determined to be of limited resource value, i.e., can never be fishable-swimmable. No acute or consistently chronic levels of toxic conditions were recorded at any of the 71 primary monitoring stations throughout the State. All of these selected, monitored waters were considered fishable in 1980-81 compared with 89% of the stations in 1975, 88% in 76-77, and 91% in 1978-79. Approximately half of the stations, 55%, violated the fecal coliform standard 10% or more of the time. This too was an improvement from preceding years where 77% in 1977 and 70% in 78-79 were in violation. Rivers with stations where the probability of fecal coliform standard violations are so likely that swimming is not advisable include: Blue Earth River, Cedar River, Twin Cities Metropolitan Mississippi River, St. Louis Bay, Whitewater River, Root River, Red Lake River, Shellrock River, and Straight River.

Intensive investigations of water quality were conducted at 35 sites to determine appropriate effluent limits for dischargers. Violations of water quality standards for ammonia, dissolved oxygen, pH and/or fecal coliforms were documented at 24 of these locations.

Fifteen fish kills were reported in the State during these two years with industrial discharges the cause in 27% of the cases, pesticides in 13%, and natural factors in 40%. No cause was determined in 20% of the cases.

Sampling for contamination by toxics was conducted in both fish tissues and sediments. Zumbro Lake and St. Louis Bay continue to occasionally show levels of mercury near the Food and Drug Administration action level. PCBs continue to be measured in fish collected from the Minnesota River, Cedar River, Blue Earth River, St. Louis River, Mississippi River, and Zumbro Lake. Most recent data, consistent with national trends, indicate an average drop in PCBs for all stations on the Mississippi River of 49%. PCB contamination of the sediment is a problem in the North Channel of St. Louis Bay, Austin Mill Pond of Cedar River, and Pipestone Creek below Pipestone. Polynuclear aromatic hydrocarbons (PAHs) have now been detected in the sediments of two river systems, the St. Louis River and Pipestone Creek. Further testing to determine the extent of PAH contamination is occurring on the St. Louis River.

Case studies of pollution control efforts were made of the Minnesota River, St. Louis Bay, and Mississippi River. The physical land characteristics of the Minnesota River watershed, combined with agricultural land use practices, presently dictate the quality of the river water. Since nonpoint source inputs of nutrients and suspended solids are so substantial, no immediate improvement is projected in the river water quality.

Elimination of several municipal and industrial point source discharges and construction of a new, sophisticated regional municipal treatment plant at Duluth have dramatically improved water quality in the St. Louis Bay. The effectiveness of point source control here has been demonstrated with improving trends in total phosphorus, total ammonia, BOD, and dissolved oxygen.

The costs and benefits of achieving the fishable-swimmable goal in the Twin Cities Metropolitan area of the Mississippi River were evaluated. Problems which continue to plague the river include water quality standard violations for dissolved oxygen, ammonia, and residual chlorine; contamination with industrial wastes such as copper, cadmium, and mercury; and combined sewer overflows. Combined sewer overflows are the primary obstacle to achievement of the swimmable goal in this area.

After sampling and data evaluation, 500 of Minnesota's lakes were categorized: 70% exhibited characteristics of eutrophication, 26% were of transitional quality, and 4% were of low fertility. Although no lakes in Minnesota have been found to be either acidic or acidified, some 2,500 to 3.700 lakes are potentially sensitive to acid rain.

Since 1978, the routine ground water monitoring program has sampled 318 wells/springs in order to characterize 12 principal aquifers in the State. Identification of sites of known ground water pollution have been made through the efforts of two Agency teams. The Hazardous Waste Strike Force logged 54 sites Statewide where improper disposal of hazardous waste has resulted in ground water contamination. The Emergency Response Unit is monitoring 32 sites contaminated by spills and leaks.

Mississippi

For complete copies of the Mississippi 305(b) Report, contact:

Mississippi Department of Natural Resources
Bureau of Pollution Control
P.O. Box 10385
Jackson, MS 39209

Summary

Current water quality and trends were evaluated for 36 major ambient stream monitoring stations operated in the State. The Bureau of Pollution Control has documented the maintenance of good water quality or improvements in water quality at 31 of these 36 stations. Each stream was evaluated using existing data, including physical-chemical parameters, fish flesh analyses, and biological evaluations.

A compilation of all existing water quality data for 28 significant lakes in the Mississippi Delta was completed as part of the Agricultural Assessment in 208 Planning. Lakes found to be most heavily polluted by agricultural nonpoint sources are Swan Lake, Six-Mile Lake, Horseshoe Lake, Pinchback Lake, Roebuck Lake, Lake Henry, and Hampton Lake. The lakes most heavily polluted by bacteria from residential areas are Blue Lake, Moon Lake, and Tchula Lakes. Fish data in the lakes reveal significant declines of DDT and its derivatives and toxaphene since 1976. Additional assessments of lakes in the State will be completed as part of the Clean Lakes Program during 1982.

Special Environmental Problems

Gulf Coast Bacteria Studies - Since 1973, the Bureau of Pollution Control has collected fecal coliform data along the swimming beaches of the Mississippi Gulf Coast. Significant improvements, especially at Ocean Springs Harbor, should be realized with implementation of ongoing facilities planning. A model procedure is being developed to help track down and correct sources of bacterial contamination from storm drains.

Chlordane Problem in the Mississippi River - The Bureau of Pollution Control is currently assisting the State of Tennessee in assessing an apparent chlordane problem in fish in the Mississippi River near Memphis. The State will collect fish at three locations during 1982.

Pollution Problems in Petroleum Producing Areas - An ongoing study has revealed that oil field activities in the past have apparently caused pollution problems in streams and ground water in some sections of the State. These problems may be due to improper salt water disposal. Significant improvements in disposal techniques have been implemented in recent years.

Ground water - An assessment of ground water pollution problems was made. Problems were found due to overpumping, oil field contamination, surface contamination, and natural conditions.

Drinking Water Supplies - Only three cities in Mississippi use surface water supplies. These are Columbus, Jackson, and Meridian. Each of these cities is experiencing problems caused by increased urban growth.

The major water pollution problem areas in Mississippi are the Mississippi Gulf Coast and the Mississippi Delta. Other problem areas are the Pearl River below Jackson; the Meridian area; the Tupelo area; the Escatawpa River; and the Bayou Casotte-Bayou Chico area.

Environmental Improvements

Numerous municipalities and industries have contributed significantly to improved water quality in the State through new construction and improved operation and maintenance of existing waste treatment facilities. Thirty-one of 36 major water quality trend stations have been documented as maintaining good water quality or showing improvements over the past seven years. During the past two years, at least 20 industries have achieved compliance with State and federal laws where they previously had been out of compliance. Regional facilities in the Jackson and Gulf Coast areas are progressing rapidly and will be in operation in the near future. An innovative lagoon treatment system known as Hydrograph Controlled Release has been developed by the State and should enable numerous towns to meet water quality standards. Finally, between 20 and 25 municipal construction grant projects will be completed this fiscal year. These new treatment and collection systems should contribute greatly to improving water quality.

Missouri

For complete copies of the Missouri 305(b) Report, contact:

Missouri Department of Natural Resources
Division of Environmental Quality
P.O. Box 1368
Jefferson City, MO 65102

Summary

The mandate to protect water quality in Missouri has been given to the Department of Natural Resources through both Missouri and federal Clean Water Laws.

The Department recognizes two basic kinds of water pollution and uses different strategies for their control. Point source discharges, those that come from a discrete source such as the end of pipe, receive most of the Department's attention. In the last few years, however, increasing attention has focused on identifying nonpoint water pollution sources, primarily surface runoff from agricultural and mined lands and from urban areas.

The quality of Missouri streams and lakes is monitored at many locations by various government agencies and certain other organizations. The most comprehensive monitoring is done by the U.S. Geologic Survey (USGS), which maintains 13 stations across the State that are sampled every 2 months, and by the Missouri Department of Natural Resources, which cooperates with USGS in monitoring 15 stations across the State on a monthly basis.

The Department of Natural Resources issues the National Pollutant Discharge Elimination System (NPDES) permits for Missouri. All point source dischargers are required to obtain a permit that stipulates the amount and/or the concentration of contaminants within wastewater that can be discharged. The permit process allows the State to maintain records of the amounts and kinds of pollutants being discharged, and the location of the discharge.

As the relationship between point source discharges and the waters being protected is understood more clearly, the NPDES permit process should be the most effective administrative method to match levels of wastewater treatment with instream water quality needs.

Section 208 of the federal Clean Water Law amendments, PL 95-217, called for the development of plans to control all water pollution sources. Three separate nonpoint planning areas have been designated: the St. Louis area, the Kansas City area, and the remaining parts of the State. A summary of the results of 208 planning in Missouri is given.

The first step in the water quality management process, and the main purpose of this report, is to identify water quality problems. General and specific water quality problems are discussed for each of the eight major basins in the complete report.

Montana

For complete copies of the Montana 305(b) Report, contact:

Montana Department of Health and Environmental Sciences
Water Quality Bureau
Cogswell Building
Helena, MT 59620

Summary

There is a large backlog of water quality problems in Montana; most of these problems date back to an era of resource exploitation before laws were enacted to protect the environment and before the relationship between a clean environment and human health and prosperity was understood. Efforts to correct these problems are shared by many government agencies and citizen groups, but continue to be hampered by a severe shortage of planning and implementation funds.

Montana's "Big Three" water quality problems are sediment, salinity and water depletion. These problems are, for the most part, the consequence of intensive agricultural practices on an erosive, salt-rich and sometimes water-poor landscape. Collectively, they account for more than 4,000 miles of degraded streams. They have been present in Montana for a long time and are expected to continue as long-term problems.

There are also other major problems. Acid mine drainage has affected many western mountain streams since the days Montana first became known as the "Treasure State." Careless disposal of toxic and hazardous wastes, much of these from the early mining industry, threaten water quality and public health. Historic overcutting and natural deforestation of some timbered watersheds have caused severe erosion, sedimentation, and hydrologic instability.

The Clean Water Act goal of "fishable and swimmable waters" by 1983 will not be met for more than 200 stream segments in Montana. Without an infusion of implementation funds for correcting existing nonpoint source pollution problems, the list of problem segments won't be much shorter when Montana's next water quality report is written in 1984. But with adequate funding for the pollution control programs described in this report, the list should not be longer.

Recent data were available to evaluate problem severity on 99 of the 216 apparent and potential problem stream segments in Montana. Of these, 32 problems were judged to be largely man-caused and improvable under the existing regulatory framework and pollution control programs. Muddy Creek near Great Falls is Montana's worst documented water quality problem.

Ground water represents only a small fraction of the water used in Montana, but it is often the only available source of potable water. Major categories of ground water contamination are saline seep, mining, accidental spills and leakage, septic tank drainfields, oil and gas exploration and development activity, solid waste disposal sites, and municipal and industrial wastewater disposal systems. Although there are many isolated cases of ground water pollution from surface activities, no widespread contamination of drinking water aquifers has occurred.

This report also discusses five water quality issues which the State believes will be gaining importance in the future: acid deposition, especially in northwestern and southcentral Montana; ammonia discharged from eight community treatment plants which is thought to affect aquatic life; energy development, which will require careful planning if surface and ground water pollution is to be avoided; placer mining, which is difficult to monitor but causes sedimentation and other effects; and toxics, which are not currently a problem but could become so.

Many government agencies and local water quality improvement projects are chipping away at the backlog of nonpoint problems. Water pollution control structures have already been installed along Bluewater Creek in Carbon County to correct a long-standing streambank erosion problem. Farmers along Pipestone in Jefferson County have a plan for managing a similar problem and will be approaching the 1983 Legislature for implementation funds. Nevertheless, without a massive infusion of implementation funds, there is little hope for a general improvement in water quality Statewide.

More success has been achieved in point source pollution control. Six stream segments listed in the 1976 water quality report as impaired by municipal wastewater discharges were eliminated as problems for this year's report either because of improved treatment provided by upgraded facilities, or because of greater resolution of the instream effects, achieved by intensive surveys.

Nebraska

For complete copies of the Nebraska 305(b) Report, contact:

Nebraska Department of Environmental Control
Water Pollution Control Division
Water Quality Section
P.O. Box 94653
State House Station
Lincoln, NB 68509

Summary

Stream water quality was assessed in each of Nebraska's 13 major river basins. This appraisal was made from water quality data collected from the ambient monitoring network and intensive surveys. The assessment was divided into two phases: 1) historic water quality, and 2) existing quality (1980-1981).

A brief overview of general water quality trends for basins of the State, as depicted by Water Quality Index values, is presented. Generally, data collected over the previous five to ten years seem to suggest that most streams in Nebraska possess relatively good water quality. For the most part, water quality remained unchanged, with a few instances of improvement (Papillion Creek - Missouri Tributaries River Basin) and degradation (Lodgepole Creek - South Platte River Basin). Historically, stream water quality in the eastern one-third of the State appeared to be of a lesser quality than in the rest of the State. This can be attributed to the more intensive agriculture practices and the presence of more urban commmunities in eastern Nebraska. The basin in which the greatest water quality improvement has occurred is the Missouri Tributaries Basin. The Papillion Creek Watershed, particularly the West Branch of Big Papillion Creek and Big Papillion Creek, has exhibited the greatest improvement in water quality. The reason for this improvement is the completion and use of an interceptor system to collect sewage from the surrounding metro-Omaha area and carry it to the Papillion Creek Sewage Treatment Plant.

The point sources which most frequently affect Nebraska's water quality, or have the potential to do so, are municipal sewage treatment plants, industries, livestock confinements, and mining activities. The most important nonpoint sources are urban stormwater runoff, livestock grazing, agricultural runoff, and irrigation return flows (physical impact).

The construction grants program has been successful in improving waste treatment and the subsequent protection of beneficial uses ascribed to Nebraska waters. A survey developed by EPA in 1980 estimated that nearly 362 million dollars would be required by the year 2000 to meet the needs of system components eligible for funding in Nebraska. However, future availability of funds is projected to be less than this need. Therefore, future funding priorities must focus on assisting communities located on high priority waters, where the greatest benefit can be realized.

The table below presents a summary of Nebraska's water quality for the past five to ten years for 13 river basins.

River Basin	General Overall Water Quality	General Overall Water Quality Trends	General Comments
Big Blue	Fair/ Good	Relatively Unchanged	Water quality appeared to have deteriorated in the upper reaches of the Big Blue River
Elkhorn	Fair/ Good	Unchanged	Water quality of the Elkhorn River appeared to have become somewhat degraded in a downstream direction
Little Blue	Fair/ Good	Unchanged	Water quality throughout the basin seemed to exhibit significant yearly variation
Loup	Very Good	Unchanged	Streams with very high water quality are located within the basin
Lower Platte	Fair/ Good	Unchanged	Water quality in lower reaches of Salt Creek appeared to be relatively poor
Middle Platte	Good	Unchanged	Water quality in the Platte River within the basin appeared quite good
Missouri Tributaries	Fair	Improved	Water quality in the lower Papillion Creek system was markedly improved after an interceptor system was installed
Nemaha	Fair/ Good	Unchanged	Water quality throughout the basin appeared subject to yearly variation
Niobrara	Very Good	Unchanged	Water quality of the Niobrara River appeared to have remained stable and is quite good
North Platte	Very Good	Unchanged	Water quality throughout the basin appeared to be quite good
Republican	Good	Unchanged	Water quality throughout the basin is relatively good, though subject to yearly variation
South Platte	Good/ Poor	Unchanged/ Degraded	Water quality in the South Platte River appeared relatively good. Lodgepole Creek appeared to have deteriorated to a poor quality
White/Hat	Very Good	Unchanged	Water quality of the White River appeared quite good

Nevada 1980

For complete copies of the 1980 Nevada 305(b) Report, contact:

Department of Conservation and Natural Resources
Division of Environmental Protection
Capitol Complex
Carson City, Nevada 89710

Summary

The quality of the major water courses of the State of Nevada—the Colorado, Humboldt, Truckee, Carson and Walker Rivers—are discussed below.

The Colorado River met water quality standards, provided for the protection and propagation of fish and wildlife, and allowed for excellent recreational activities in and on the water. The high water level in Lake Mead probably contributed to the conditions by diluting the high pollutant loads entering Lake Mead via Las Vegas Wash. The Virgin River, a tributary to Lake Mead, exhibited poor water quality in terms of bacteria, aesthetics, solids, inorganic toxicity, and very minimal fish life.

The Humboldt River, in general, met water quality standards except for severe violations of turbidity standards in the upper reaches and phosphate standards in almost all reaches. The river has a highly variable flow with a major irrigation-recreation reservoir on the lower end of the system and a terminal sink. High nutrient loads and ambient air temperatures contribute to aesthetically displeasing conditions below the reservoir. Although the sink is highly saline, it supports a balanced wildlife habitat. The various communities along the river system have either moved or are moving to land application as the treatment method for their wastewater. This will result in reduced organic and nutrient loads.

The Truckee River showed improvement in aquatic life below Reno/Sparks because of control on toxics. However, there were severe violations of phosphate standards downstream of Reno/Sparks with resultant nuisance and aesthetic problems. The lowest control point on the river experienced temperature, pH, nutrients, and inorganic toxicity problems. The river provides for the protection and propagation of fish and wildlife and allows for recreational activities in and on the water. However, due to low flow conditions, denuded banks, channelization, and man-made barriers in the lower reaches, natural spawning of cutthroat trout does not occur. The reduction of nutrient loads will improve the conditions for fish in the stream and for fish and recreation at Lake Lahontan and Pyramid Lake.

The Carson River's water quality standards for nutrients were frequently exceeded for all reaches, including that point where the river enters the State. The greatest violations of standards occurred during the summer months below Carson City, when extreme low flow occurred and wastewater effluent was the majority of the flow in the stream. An intensive survey conducted in August and September indicated that the salinity of the river in 1979 was the same as in 1966. At the time of the survey, irrigation returns were minimal, only one treatment plant was discharging to the river, and river flow was very low. The survey also revealed that all reaches above the treatment plant were of suitable quality for all beneficial uses, and that reaches below the treatment plant had high nutrient values which affected the suitability of the river for aquatic life, aesthetics, and recreation. Water quality measurements in Lake Lahontan also showed high nutrient concentrations with large algal blooms which interfered with aquatic life, aesthetics, and recreation. The planned upgrading of municipal discharges will begin to reverse the trend of deterioration which has been occurring over the last thirteen years.

Walker River water quality data reflected minor violations of water quality standards for dissolved oxygen, temperature, nutrients, solids, and aesthetics with no appreciable effect on aquatic life, recreation, or other beneficial uses. However, reports were received of effects on agricultural use because of high sediment loads being deposited in irrigation ditches and fields. No municipality in Nevada discharges to the Walker River.

An evaluation of recreational use impairment of 11 lakes in Nevada by EPA Region 9 indicated that one lake was severely impaired for swimming and aesthetics; two lakes were moderately impaired for aesthetics; three lakes were moderately impaired for swimming and boating; and four lakes were moderately impaired for fishing.

The implementation of proposed sewerage projects through FY 85 totaling approximately $105 million in estimated EPA assistance, along with implementation of best management practices for new and existing development and on farms and ranches, should result in improvement of the Truckee, Carson, Humboldt and Colorado river systems as well as some minor river systems. Fish propagation and water-related recreational activities will be protected.

Implementation of the proposed sewerage projects is significant in meeting the 1985 goals of the Clean Water Act, since the majority of the projects will be using some form of land application.

Agriculture and rangeland are two nonpoint sources which contribute large sediment loads to Nevada's waters. Urban drainage systems contribute nutrients, heavy metals, and organic loads. Nonpoint source problems caused by existing on-lot disposal will be resolved by implementing sewerage projects which eliminate on-lot disposal. Strict enforcement of regulations for on-lot disposal and permitting of subsurface disposal systems will prevent such disposal methods for new development from causing ground water pollution or nonpoint source problems.

New Hampshire

For complete copies of the New Hampshire 305(b) Report, contact:

New Hampshire Water Supply and Pollution
Control Administration
Hazen Drive
P.O. Box 95
Concord, NH 03301

Summary

This report is intended to provide an assessment of the status of water pollution control programs in New Hampshire and to fulfill the requirements of Section 305(b) of the 1977 Clean Water Act (PL 95-217). As such, it represents an evaluation of progress toward the attainment of classified water quality and the goal of fishable/swimmable surface waters set for July 1, 1988.

The table below provides a basin-specific summary of the water quality of New Hampshire streams. Approximately 507 river miles of the total 14,500 miles of streams are currently violating water quality standards. This represents only 3.5% of total stream miles but includes economically and recreationally important river segments. About 97 miles of surface waters have improved since the 1980 Report to Congress and are now fishable/swimmable according to New Hampshire water quality criteria.

Water Quality Summary

River Basin	Total River Miles Violating Water Quality Standards	Total Miles Not Expected to Meet Class B or Better by July 1, 1988	Total Miles Upgraded Since 1980 Report to Congress
Androscoggin	19.1	16.8	2.5
Connecticut	273.7	20.4	33.3
Merrimack	152.3	15.0	36.9
Piscataqua and Coastal	61.4	0	24.0
Saco	0.4	0	0
TOTAL	506.9	52.2	96.7

This table notes that aproximately 52 miles of river are not expected to meet Class B or better by July 1, 1988. This represents less than one half of one percent of total stream miles. These are legislatively classified "C" segments that will in most cases attain legal "C" standards by this date and will, therefore, be fishable. It is expected that by 1988 more than 99 percent of assessed river mileage should meet Class B (fishable and swimmable) standards or better, based on expected continuation of the federal construction grants program.

Major remaining point source problems involve the discharge of inadequately treated municipal and industrial wastes, combined sewage, and untreated domestic discharges. The resolution of many of these problems hinges on the construction grants program, State resources, and local resolve.

Widespread water quality degradation caused by nonpoint sources of pollution (agricultural runoff, leachate from landfills, etc.) has not been documented. Local areas of ground and surface water impacts from such sources are known but are limited in extent.

Several illegal hazardous waste sites have been discovered over the last two years including the well documented Sylvester (Gilson Road) site in Nashua. Significant federal, State, and local resources have been drawn upon to cope with existing problems.

Recent lake studies have attempted to evaluate problem lakes as well as clean lakes. One Clean Lakes grant allowed for the inventory and classification of 171 of New Hampshire's more than 1,300 lakes and ponds. Information and priority rankings for needed restorative and protective measures are presented in the New Hampshire report.

The impact of acid precipitation on New Hampshire lakes and streams is receiving increasing investigation. Current information indicates that residual buffering capacity in at least 23 lakes is nearly or completely depleted. Once the alkalinity is gone, the lake pH drops and drastic changes in aquatic life occur.

Due to the potential for long and short term impacts to water quality, fish, other aquatic life, and wildlife associated with oil spills, New Hampshire has undertaken comprehensive oil spill control and prevention programs. Over the past three years, nearly 300 spills or oil-related complaints have been investigated.

The costs for providing for pollution abatement have been significant. Construction grants, including State and federal shares, for publicly-owned wastewater treatment facilities during 1980 and 1981 totaled 95 million dollars. Future costs for wastewater facilities and appurtenances to achieve the 1988 goals and use classifications for New Hampshire streams are provided based on the 1980 Needs Survey performed jointly by EPA and the State.

New Jersey

For complete copies of the New Jersey 305(b) Report, contact:

New Jersey Department of Environmental Protection
Division of Water Resources
P.O. Box 1390
Trenton, NJ 08625

Summary

Surface Waters

Surface waters in New Jersey have shown no significant improvement or decline in quality over the last 4-5 years based on conventional data collected at the monitoring stations reviewed in the surface water quality inventory. Overall, for conventional data reviewed in the 1982 water quality inventory which can be compared to respective State Surface Water Quality Standards, these standards were exceeded by 45 percent of the total phosphorous values, 4 percent of the dissolved oxygen values, 3 percent of the un-ionized ammonia values, and 2 percent of total dissolved solids readings. In addition, the data indicate that widespread fecal coliform contamination exists in the surface waters of the State. The sources of bacteria are, for the most part, nonpoint in origin (based on the assumption that point sources of pollution are properly disinfecting) while the nutrients (phosphorous) originate from both point source discharges and nonpoint runoff. Because of the large percentage of samples containing high total phosphorous concentrations, most standing waterbodies in the State have excessive aquatic plant growth and are classified as eutrophic.

Many streams in northeastern New Jersey (Passaic, Hackensack, and Raritan River basins) experienced significantly reduced water quality between the summer of 1980 and early 1981 because of a severe lack of rainfall. The water quality impacts of the drought were generally reflected in reduced dissolved oxygen (DO) readings and increased fecal coliform, biochemical oxygen demand, nutrient, and un-ionized ammonia concentrations. By the end of the monitoring period used in this report (mid-1981), waterways had shown general recovery to pre-drought conditions. Stress to aquatic life probably occurred during the drought because of the reduced DO and increases in un-ionized ammonia concentrations.

The NJ Divison of Fish, Game and Wildlife has found in studies of coastal bays and estuaries that very low DO levels often occur in these waters during summer months. Because of these low DO levels, the coastal bays and estuaries are very sensitive to oxygen-demanding pollution loads.

Toxic chemicals (including volatile organics, pesticides, PCBs, and heavy metals) in the water column, sediments, and fish tissue seem to be fairly widespread at very low concentrations, depending on the substance and the medium sampled. Volatile organics were found at their highest levels in waters adjacent to or flowing through industrialized urban/suburban centers. Metals, PCBs, and pesticides were found throughout the State in fish tissue, but appeared highest in catadromous and anadromous fish species. A review of the effects of toxic contaminants on both aquatic and human health is available from the NJ Division of Water Resources.

Ground Waters

The major ground water concerns outlined in this report deal with both quality and quantity. A lowering of ground water levels in many of the coastal plain ground water-bearing formations (aquifers) is occuring due to overpumpage. This is affecting both quality and quantity of these formations. Overpumping also affects baseflows to streams in the area since ground water is a major contributor to stream flows. More efficient use of the relationship between ground and surface waters is suggested for the coastal plain region of New Jersey.

Across the State, ground water quality is generally suitable for drinking water purposes without treatment. The common natural quality problems include high iron, dissolved solids, manganese, and hardness levels due to the natural quality of rock and sand formations. Other quality problems are occurring because of localized ground water pollution and salt water intrusion. Salt water intrusion is occurring at various locations along the coast of Raritan Bay, the Atlantic Ocean, and tidal Delaware River as a direct result of excessive pumping. Ground water pollution occurs from a variety of sources including landfills, surface impoundments, accidental spills, on-site waste water disposal systems, and numerous other sources. Currently, the NJ Department of Environmental Protection has closed 74 public supply wells and 697 non-public supply wells since 1971. Most of these wells are closed because of excessive organic and industrial chemicals.

New Mexico

For complete copies of the New Mexico 305(b) Report, contact:

New Mexico Water Quality Control Commission
P.O. Box 968
Santa Fe, NM 87504-0968

Summary

Ground Water Quality: The New Mexico Environmental Improvement Division (EID) has identified 105 sites in New Mexico with known ground water contamination problems. The nature and extent of the contamination at these 105 sites vary greatly. Twenty-five of these sites have been contaminated by organic compounds such as hydrocarbon fuels and solvents, 47 by brine or total dissolved solids, 22 by nitrates, 6 by trace metals and/or radionuclides, and 5, along shallow alluvial aquifers, by fecal coliform bacteria.

It is estimated that at least 18 percent and possibly as many as 58 percent of known contamination sites involve abandoned or currently inactive facilities. For this reason, and because the State since 1977 has pursued a vigorous program to regulate discharges to ground water, it should not be assumed that contamination continues at these sites. Nearly all of the instances in New Mexico where water uses have been affected by contaminated ground water have involved either regional saline intrusion or relatively small areas in shallow aquifers. The limited extent of contamination at most sites has been largely due to complex natural factors, rather than contaminants in a discharge.

Surface Water Quality: Data from 64 monitoring stations throughout the State for the period 1976-1981 indicate that stream water quality is good, in general, when compared to water quality standards. Water quality is consistent with standards in over 90 percent of the estimated 3,500 miles of perennial streams in New Mexico.

Significant standards violations, caused by both point and nonpoint source pollution, were recorded in an estimated 200 miles of perennial streams distributed among 6 of the 59 designated stream segments. In addition, occasional stream standards violations were recorded in eight stream segments.

In addition to these specific stream segments, more generalized problems are experienced with both turbidity and fecal coliform bacteria. Eleven monitoring stations, distributed among eight of the State's 11 water quality basins, showed between two and 15 instances of elevated fecal coliform bacteria levels. These are generally related to summer thunderstorm activity and are probably caused by nonpoint sources.

Data regarding turbidity, and the associated water quality problems of suspended sediment and total dissolved solids, have been delineated in detail in prior State water quality reports. Recent data do not provide the basis for new or more detailed conclusions regarding the water quality problems associated with these parameters. Stream turbidity standards were violated occasionally during the last five years at 13 monitoring stations; only two stations indicated five or more violations. In those stream segments which have standards for total dissolved solids, conductivity, chlorides, or sulfates, no standards violations were noted.

Limited monitoring to date in New Mexico has not demonstrated significant surface water contamination by heavy metals, trace organics, pesticides or other toxicants attributable to industrial or agricultural use.

The major improvement noted in stream quality since the State's 1980 report is in the decrease of standards violations for fecal coliform bacteria. Data for three stream segments identified in 1980 as significantly contaminated by bacteria indicate no more than one standards violation in the last two years. These segments are the Rio Grande below Las Cruces and below Espanola, and the San Juan River below Farmington. The 1980 report did note that improvements in these municipalities' wastewater treatment had recently eliminated their bacterial contamination of these streams.

New York

For complete copies of the New York 305(b) Report, contact:

Division of Water
New York State Department of Environmental Conservation
Albany, NY 12233

Summary

In New York State, the water quality management problems which most commonly contribute to serious water pollution and affect the largest percentage of the State's population are: municipal discharges; industrial discharges; residual wastes (solids and liquids); combined sewer overflows; urban storm runoff; acid precipitation; and hydraulic/hydrologic modifications.

By traditional standards used to measure organic oxygen-consuming wastes and infectious agents, the overall level of water quality indicates definite improving trends. New York State has made great progress in controlling point source discharges of raw sewage and industrial wastes. Over 90 percent of the State's 70,000 stream miles are in conformance with current water quality standards. This is a significant accomplishment of the State's water management program over the past 15 years. About 1,200 miles are affected by pollution to the degree that water use is impaired as a water supply source, unsuitable for recreation, or unable to support a balanced biological and fish population.

The construction of new and upgraded municipal sewage treatment facilities has drastically reduced the amount and/or the concentrations of pollutants entering our surface and ground water systems. The number of municipal sewage treatment plants has increased from 298 in 1952 to 509 in 1980. More significantly, the type of treatment provided by these facilities has improved substantially.

A water quality management problem which is encountered frequently in New York State is that of accidental leakage and spills of oil and other hazardous substances. Many ground water resources are sufficiently impaired to preclude utilization as drinking water, and public water supplies have been closed due to contamination.

Nonpoint sources of pollution also pose potentially serious water quality management problems throughout the State. However, the magnitude and severity of these problems vary widely, depending upon the type and location of the nonpoint source activity. Agricultural practices, silviculture, construction activities, and acid precipitation are recurrent problems. A number of nonpoint source pollutants have been identified; the extent or degree to which they affect water quality has not been fully assessed. Appropriate water quality management programs will be developed to help solve those problems which may be identified as severe.

New York's most serious current water quality problems relate to toxic substances in the environment. In the mid-1970s, attention was directed to a "second generation" set of problems associated with the disposal of toxic effluents and residual wastes. In an effort to more closely define the problems asociated with toxic substances, New York's Division of Water conducted a survey of New York industries to track down the exact types and amounts of chemicals being used or manufactured in the State and instituted sampling of waterways, sediments, and fish flesh to determine levels of toxic substances in the environment. In some cases where toxic substances have been identified and their passage into receiving waters can be traced to industrial discharges, permit controls have been instituted to control releases. In other cases, it is suspected that some toxics may be transported into receiving waters through runoff from nonpoint sources.

North Carolina

For complete copies of the North Carolina 305(b) Report, contact:

North Carolina Department of Natural Resources
and Community Development
Division of Environmental Management
Raleigh, NC 27611

Summary

North Carolina is divided into three distinct regions, each of which has its own unique water resource benefits and problems. The mountain region is characterized by high mountain peaks, dense woodlands, and relatively sparse population (15% of the State's population). The water quality in this region is good with the many spring fed mountain streams providing high quality waters which support many excellent trout fisheries. While the cold turbulent waters of this region are capable of assimilating much larger quantities of oxygen consuming materials than the Piedmont and Coastal waters, the protection of sensitive fish species such as trout requires that even slight degradation of water quality be prevented. It is estimated that recreational fishing across the State generates revenues of over $300 million annually.

The Piedmont region is characterized by much lower elevations and gently rolling hills. Since this region is the most populated (53% of the population) and industrialized area of the State, a tremendous demand is placed on water resources. Not only does the Piedmont region contribute the heaviest waste load to the waters, but it also has the greatest demand for clean water for public and industrial consumption and for recreation. As would be expected, the majority of the State's water quality problems occur in this region.

The Coastal Plain region is characterized by generally flat terrain spanning from the higher elevations near the Piedmont to the low lying swamplands in the east to the sandy beaches of the coast. The water quality in this region is generally good except in areas of dense population (32% of the State's population lives here). The waters in this region have higher temperatures and are slow moving and sluggish, thus they can assimilate much less oxygen demanding substance. Drainage from the swamplands often causes naturally occurring low oxygen levels, low pH, and high color in streams in the area. Since the coastal waters receive the residues from the interior parts of the State, there is potential for water quality problems, especially deposits of harmful substances and nutrient over-enrichment, in the bays and sounds inside the Outer Banks. The protection of fish and shellfish in the coastal waters is especially important in this region since the harvesting of shellfish and commercial sport fishing is a major resource of the area.

Progress has been made in cleaning up pollution on all fronts. Not only were a few new areas in coastal waters classified as shellfish waters, but over 100,000 fewer acres of shellfish waters had to be closed because of pollution. Better cooperation on limiting sediment from construction operations is being obtained as more people become aware of the problem and understand ways to limit the transport of sediment. Agricultural activities continue to contribute sediment and nutrients to waterways but, again, education is slowly making a difference.

The number of degraded streams or stream segments that do not meet the stream standards a significant proportion of the time has been reduced from 410 in the last biennium to 259 at the end of 1981. Also, the number of streams that carry dissolved oxygen and/or coliform exceptions to their standards was reduced from 35 to 27.

Drinking water supplies have continued to meet all standards with very few exceptions. The focus on trihalomethanes (THMS)—carcinogens that are formed when natural organic constituents of surface waters are disinfected by using chlorine—has led to modifications in the treatment process. So far the standards have been met, though in some cases this was a difficult task.

North Carolina has a long coastline. Problems arise in the estuaries from septic tank nitrification line seepage; nursery areas are affected by fresh water flushes during wet periods from excessive drainage from ditched agricultural lands. This problem will require a solution in the near future if nursery areas are to be preserved.

Several programs have a large impact on State water quality. The construction grants program, for which funding is now being reduced, has made possible the large increase in the number of treatment plants that can adequately treat the waste they receive. The North Carolina Waste Water Treatment Plant Operator Training and Certification program plays a large part in making treatment plant operation reliable and in ensuring that plant effluents meet the criteria for which the plant was designed. The Environmental Laboratory not only provides analytical information but also has a certification program for commercial laboratories.

North Dakota

For complete copies of the North Dakota 305(b) Report, contact:

North Dakota State Department of Health
Division of Water Supply and Pollution Control
1200 Missouri Ave.
Missouri Office Building
Bismark, ND 58505

Summary

Water quality degradation of the streams located within North Dakota results primarily from natural substances occurring in the soils of the State and is aggravated by a number of point and nonpoint sources.

Presently there are no municipal facilities in North Dakota discharging completely untreated wastes into the waters of the State. Some, however, provide less than the desired level of treatment for several reasons, such as a lack of storage capacity or a lack of resources to provide upgraded treatment. A number of municipalities will need additions, modifications, and completely new facilities in order to comply with permit requirements.

There do not appear to be any significant stream degradation problems from major industrial dischargers. Major industrial sources include power plants, sugar beet processing plants, and oil refineries. Minor industrial sources include potato washing plants, sand and gravel operations, water treatment plants, and coal mines. Most industrial and municipal point source discharges are intermittent discharging stabilization ponds or lagoon systems.

There are a few combined sewer systems located in the older cities in the State. The major problem with combined sewers is the overflow discharge of diluted, untreated wastewater to a stream or other receiving body as a result of intermittent heavy flows due to rainstorms or snowmelt. Most of the affected cities are presently involved in combined sewer separation projects.

North Dakota's nonpoint source pollution control programs have achieved significant success in certain areas during the past years. These programs can be divided into two areas of emphasis: watershed controls that are an integral part of lake restoration projects, and demonstration projects which serve education/research purposes.

Nonpoint pollution sources are responsible for most of the surface water degradation in North Dakota. The Department's Surface Water Quality Monitoring Program has indicated that the quality of surface waters has not been enhanced in proportion to the rapid advances that have been achieved during the past years by municipalities, industries, and other point sources in providing adequate treatment of their wastes. Violations of certain parameters of the State's Water Quality Standards have been noted at times when records reveal there have been no discharges into the stream from point sources. Nonpoint pollutants include sediment and plant nutrients, wastes from stock raising activities, and runoff from croplands, rangelands, pastures, farmsteads, and urban areas containing nutrients, pesticides, and other pollutants.

The water quality problems associated with the major drainage basins of the State are noted in detail in the water quality analysis section of the North Dakota report. Phosphorous is the only parameter which was found to be a problem in most streams. Agricultural Best Management Practices which reduce soil loss may reduce the amounts of phosphorous in runoff to a level approaching that of natural or baseline conditions. Historically, dissolved solids concentrations may reach impairing levels in nearly all streams and rivers in the State during low flow conditions, which normally occur in late summer, fall, and winter.

North Dakota has experienced only minor ground water quality problems. Contamination of aquifers has been limited to small areas and aquifers of poor quality, and has been caused by bacteriological contamination of shallow aquifers by septic tank drainfields, leachate from solid waste disposal sites entering the ground water, and natural sources of contamination. A large portion of the State's ground water resources are located at a depth which naturally protects them from manmade sources of pollution. The areas where shallow table aquifers exist have experienced very few contamination problems due to the absence of industry and other detrimental land uses above these aquifers.

Although the State has encountered only minor ground water contamination incidents, the potential for future incidents exists. The North Dakota State Department of Health, in conjunction with the North Dakota Geological Survey, has completed a surface wastewater impoundment assessment; it indicated that many surface impoundments are sited in geologically poor conditions and therefore have high pollution potentials. Also, potential ground water quality problems exist in the western part of the State due to mining, oil and gas exploration, and other energy related impacts.

Northern Mariana Islands

For complete copies of the Northern Mariana Islands 305(b) Report contact:

Division of Environmental Quality
Doctor Torres Hospital
Saipan, Mariana Islands 96950

Summary

This is an update of the 305(b) report submitted by the Commonwealth of the Northern Mariana Islands to the U.S. Environmental Protection Agency in 1980. Only those areas with significant changes in status are discussed in this update.

Tourism remains the major industry in the Commonwealth, and the same basic problems remain: sewage disposal, ground water protection, and the prevention of environmental damage from earthmoving activities. Improvement of the drinking water supply for Saipan remains a high priority.

In response to the Governor's declaration of a Water Emergency on Saipan, a new well drilling program was started in January 1982. This program has concentrated on drilling wells in known water-producing areas. Fifteen wells have been completed to date. Many of these wells are capable of producing water of acceptable salinity and will be put into service to replace some of the older, brackish water wells.

All of the producing water wells are included in a monthly monitoring program to determine the fluctuations of water quality with time and pumping rate. The parameters measured include chloride, alkalinity, dissolved solids, conductivity, and pH.

Ohio

For complete copies of the Ohio 305(b) Report, contact:

Ohio Environmental Protection Agency
P.O. Box 118
Columbus, OH 43215

Summary

Approximately nine percent of the 43,900 permanent stream miles in Ohio have been evaluated in this report; however, 32 percent of the "principal" rivers and streams in Ohio (all subbasin mainstems plus streams draining at least 100 square miles) were evaluated. The quantity of data needed to make an evaluation was not standardized, but consisted in most cases of at least four samples per year at one or more stations. Segment delineation was usually based upon the location of sampling stations in relation to major point source dischargers and major tributary streams. Data were not extrapolated beyond significant point sources or major tributaries.

The Ohio 305(b) report contains information on administrative programs, monitoring programs, intensive surveys, lakes and reservoirs, wetlands, Lake Erie beaches, ground water, nonpoint sources, and specific chemical, physical, and biological evaluations of water quality. These subbasin evaluations reveal that Ohio's water quality is generally good. However, some segments such as lower Swan Creek and the Cuyahoga River below Akron are not expected to meet water quality goals. Municipal and industrial point source discharges and nonpoint source runoff are reported as the most common causes of water quality degradation. Significant water quality improvements have been noted in many areas, primarily due to point source controls such as municipal and industrial treatment plant upgradings.

The coastal wetlands of Lake Erie are the most extensive in Ohio. The wetlands inventory conducted in 1954 estimates that 30,000 acres of wetlands existed adjacent to Lake Erie; by 1974, only 15,000 acres of wetlands remained. Destruction of the coastal wetlands is largely attributable to development. Wetlands have been and continue to be drained, dredged, or filled for agricultural, industrial, and residential expansion. Those that survive development are generally degraded.

One hundred and nineteen (54%) of the lakes listed in Ohio EPA's public lake inventory have been classified according to trophic status. Of these, 73% were classified eutrophic, 16% were classified mesotrophic, and 11% were classified hypereutrophic. Sedimentation is also a problem in many Ohio lakes. Metal concentrations that exceeded Ohio water quality standards were observed in 34 lakes. Copper was the metal that most often exceeded Ohio water quality standards. The use of copper herbicides for the control of algae in the 21 affected lakes could be a contributing factor. The sanitary water quality of Ohio's lakes was generally within water quality standards. High fecal coliform and/or fecal streptococcus bacterial counts were associated with storm runoff events or increases in lake water levels.

The State of Ohio has abundant ground water resources due to a rather humid climate and favorable geologic conditions. Nearly 45% of Ohio's population use ground water as a drinking water source. Ground water is also widely used for industrial, agricultural, and commercial uses. Overall, ground water in Ohio has not been contaminated to any significant degree, and for the most part meets all primary drinking water standards without treatment.

Ohio River Valley Water Sanitation Commission

For complete copies of the Ohio River Valley Water Sanitation Commission 305(b) Report, contact:

Ohio River Valley Water Sanitation Commission
414 Walnut Street
Cincinnati, OH 45202

Summary

This report, prepared by the Ohio River Valley Water Sanitation Commission (ORSANCO), is an assessment of the water quality of the Ohio River and the lower reaches of its major tributaries together with information on Commission water pollution control programs for the years 1980 and 1981. The Commission is an interstate agency formed in 1948 by eight States signatory to a compact to abate existing and control future water pollution in the Ohio River Valley. This assessment is based upon data gathered from the Commission's operative monitoring systems.

Fifteen of the 20 substances for which the Commission has recommended criteria were within acceptable levels 100 percent of the time during 1980 and 1981. Of the five remaining—fecal coliform bacteria, phenolics, cyanide, dissolved oxygen (DO), and mercury—cyanide levels showed marked decreases from previous years while the other four continued to present problems. Fecal coliform bacteria levels, indicators of contamination from human and animal waste, were improved at some locations but degraded at others in comparison to previous years. The number of phenolic detections increased in the lower river and remained a persistent problem in the upper river. A phenolics reconaissance in the upper river was initiated in late 1981 in preparation for an intensive survey in early 1982. Further intensive surveys for both fecal coliform and phenolics may be undertaken during 1982.

Dissolved oxygen excursions were most pronounced in the middle and lower river during August and

September 1981, when dry weather and low flows combined to drop the DO level below the Commission recommended minimum level. However, no fish kills were reported on the mainstem during this period. The relatively moderate temperatures and gradual decline of dissolved oxygen may have enabled fish to acclimate to the river conditions.

The mercury criterion was exceeded most frequently in the middle river; the 1978-79 Section 305(b) report noted that values exceeding the criterion were scattered throughout the Valley. However, fish tissue samples analyzed in 1980 showed no excessive amounts of mercury.

Lead (found to be a problem in the 1976 and 1977 reports) and cyanide were found in decreasing amounts in river water during 1980 and 1981, probably due to the advent of unleaded gasoline and improved industrial waste treatment, respectively. Increased use of unleaded gasoline has probably been a major factor in the decrease in lead levels in urban runoff.

The three largest population centers (Pittsburgh, Cincinnati, and Louisville) all have secondary wastewater treatment facilities although they are not fully operational at Cincinnati and Louisville. Additionally, four major publicly-owned wastewater treatment plants are under construction in the Valley. During 1980-81, the U.S. Environmental Protection Agency awarded $39 million in construction grants for secondary treatment projects on the mainstem. In the same period, municipalities and industries in the Valley appeared to be completing projects at about the same rate that new project needs were identified. Of the treatment plants surveyed as having needs, three percent of the municipal facilities reported completion of construction to meet those needs during 1980-81, as did 21 percent of the industrial facilities.

This report serves the combined purpose of indicating water quality improvement, areas requiring further attention, and programs aimed at resolving water quality problems. The Ohio River system is ever-changing; monitoring, surveillance, and analysis programs must be flexible enough to meet water pollution control needs as they arise. The uses that the human population of the Valley puts the rivers to are multipurpose and change in emphasis with changing times. Major new developments, such as synfuels facilities, coal slurry pipelines, and low-head hydro powerplants to be installed at the Ohio River dams, as well as the expansion of already existing uses, all carry with them the potential for environmental impact. However, with informed and perceptive management and decision-making, many of these impacts can be foreseen and resolved.

Oklahoma

For complete copies of the Oklahoma 305(b) Report, contact:

Oklahoma State Department of Health
1000 N.E. 10th
Oklahoma City, OK 73152

Summary

The State's major river basins are the Red and Arkansas River Basins. The Red River shows continued enrichment and mineralization as well as elevated levels of some metals. The lower Red River below Lake Texoma displays gradual improvement, with decreasing levels of mineralization and low levels of toxic metals, but high levels of iron and manganese. Due to these factors, fish communities show increasing diversity downstream with improving water quality conditions. Tributaries in the Red River Basin are, in general, improving or stable. The one exception is the Beaver Creek watershed, which shows severe degradation primarily from increased enrichment and toxics. The Arkansas River enters Oklahoma from Kansas with poor water quality due to enrichment and mineralization. Kaw Reservoir acts as a nutrient sink and mineral assimilator, so that water quality improves downstream from the reservoir. There is a major decline in water quality downstream from Tulsa. The fish species diversity increases farther downstream as the water quality improves. Many tributaries in the Arkansas River basin show degradation. Much of this degradation is due to point source discharges from municipalities and industries. Specific tributaries with major degradation include portions of the North Canadian River, the Illinois River, and the Cimarron River. Toxic metals and organic compounds were detected at various sites in the Arkansas River basin. Another area of concern is the Tar Creek watershed, where mine drainage is causing high levels of metals in the water. A water quality assessment of Oklahoma streams, by segment, is included in the report. The matrix rates the scope, trend, and severity of various chemical parameters and the biological condition and trend for each stream segment.

The results of a study of toxics in 48 State reservoirs show that Oklahoma reservoirs are, in general, free of dangerous levels of toxic chemicals. Greenleaf and Lawtonka had no detectable levels of these pollutants. PCBs are the most common organic toxics found in fish tissue and were detected in 44 reservoirs. Nevertheless, only at Fort Gibson Reservoir were FDA Alert Limits for PCBs in tissue samples exceeded. Chlordane was found in 40 reservoirs, with only Lake Hefner and Northeast (Zoo) Lake showing levels exceeding FDA Alert Limits. DDT was present in 11 reservoirs, with the highest level found in Fort Cobb Reservoir. DDT levels were well within FDA limits. Aldrin, heptachlor, and toxaphene were present in a few reservoirs, but were also within FDA limits.

During water years 1980-81, 38 publicly owned water supplies were in violation of drinking water standards.

The parameters violated include nitrate, fluoride, selenium, chromium, barium, trihalomethanes, and bacteria. Due to potentially harmful effects on human health, limited fishing bans were placed on Fort Gibson Reservoir in response to the discovery of PCBs in several fish species. Similar bans have been applied to Lake Hefner and Northeast Lake as a result of chlordane levels exceeding FDA Alert Limits.

Over fifteen months of high-flowing sampling data has been collected from a network of 106 sites on 48 of the State's 59 stream segments. This ongoing program should, eventually, facilitate the detection of nonpoint source pollution problems and help distinguish between probable man-induced contributions and natural background levels.

Municipal point source control is largely accomplished through efforts of the Oklahoma State Department of Health, while industrial point source control is the responsibility of the Oklahoma Water Resources Board (OWRB). The nonpoint sources for the State are generally placed under the jurisdiction of the Oklahoma Conservation Commission, with exceptions in the areas of silviculture under the Oklahoma State Department of Agriculture and industrial stormwater runoff under the OWRB.

Oregon

For complete copies of the Oregon 305(b) Report, contact:

Oregon Department of Environmental Quality
Water Quality Division
522 S.W. Fifth Avenue
Portland, OR 97204

Summary

Oregon's water quality program emphasis on problem prevention has enabled the State to maintain relatively high water quality. Efforts over the last three decades have been directed toward assuring that necessary pollution controls were provided prior to approving new industrial or municipal discharges, and that as these facilities were expanded, upgraded treatment capabilities minimized waste load increases.

Whereas several years ago a large share of municipal source control activities could be devoted to long range needs for timely construction of facilities to avert pollution problems, much of the program effort today involves assisting communities in meeting their immediate needs. Postponed and insufficient federal funding of sewerage works construction has created a considerable backlog of problems. This is not intended to suggest that accomplishments in the point source control program will not continue to be made. However, expectations have been dampened regarding the ability of the State to keep pace with a preventive approach and/or make significant strides in a short time period where problems do exist. A gradual shift in the water pollution control program effort away from a preventive and toward an abatement approach is foreseen, if Oregon's poor economic conditions continue concurrent with reduced federal project funding.

The nonpoint source program has improved water quality in Oregon. Considerable time and effort have been spent developing coherent and workable management plans for solving present nonpoint source problems and preventing future problems. The major portion of Oregon's nonpoint source effort has been funded through federal grants under the Section 208 program. As a result of the nonpoint source program effort, public awareness of nonpoint source pollution has been heightened. The implementation of identified best management practices will take time, but the need for these improved management approaches has been demonstrated.

Between 1980 and 1982, significant progress was made towards reevaluating specific beneficial uses of many of Oregon's river reaches; rating these river reaches according to whether high, medium, or low use is made of each reach; and evaluating their ability to serve the most sensitive users based on the selected criteria.

Oregon has some 1,300 named lakes and hundreds of unnamed lakes, most of which are of very high quality. For the few lakes where recreational and development pressures have led to some degradation in quality, grant applications to the Clean Lakes program were made and projects are being undertaken.

The bulk of Oregon's ground water is dependable and of high quality. In a few areas of the State, ground water has naturally poor quality due to dissolved metals, gases, and minerals, and is not always suitable for drinking or other uses. Knowledge of human-caused ground water contamination problems has increased, and the need to avert the potential for more problems has resulted in the adoption of a State ground water protection policy. The policy addresses the need to protect ground water from the improper storage and disposal of wastes from industrial, commercial, agricultural, and residential activities and sources.

Pennsylvania

For complete copies of the Pennsylvania 305(b) Report, contact:

Pennsylvania Department of Environmental Resources
Bureau of Water Quality Management
P.O. Box 2063
Harrisburg, PA 17120

Summary

Most of the past emphasis in Pennsylvania water quality management programs, as well in as the rest of the Nation, has been toward elimination of point source pollution (sewage and industrial waste discharges). However, pollution from nonpoint sources such as abandoned mine drainage, storm water runoff, agricultural and earth-moving operations, oil and gas extraction activities, and discharges to ground water have significant adverse impacts in many areas of the State. Consequently, increasing program emphasis and resources are being committed to nonpoint source pollution control.

Much has been accomplished in pollution abatement in the State, and there is a continuing trend of water quality improvement. However, a number of significant problems remain, as well as a need for resources to correct these problems.

In areas with heavy industrial and population concentration, sewage and industrial wastes are the major pollution sources. Storm water runoff and combined sewer discharges add to the pollution problems. In western and parts of central Pennsylvania, drainage from bituminous coal mines (primarily abandoned mines) creates serious water quality problems. The same situation exists in the anthracite area of northeastern Pennsylvania. Approximately 2,000 miles of major streams in Pennsylvania are either acidic (low pH) or iron stained by drainage from abandoned coal mines.

Other pollution sources in Pennsylvania include oil and gas well operations in northwestern Pennsylvania, and construction and other earthmoving operations which have created serious erosion and sedimentation problems. A significant number of power plants scattered throughout the State discharge heated water, also a potential pollutant.

The success of Pennsylvania's water quality management program can best be measured by the improvement in quality of previously polluted or degraded water and by the degree to which good quality waters are protected. In 1980, there was a net degradation of 92 miles of streams. This was mainly due to the degradation of 69 miles of the North Branch of the Susquehanna River due to the discharge of oil and organic substances which had been disposed of in the Butler Mine Drainage Tunnel. In 1981, a net improvement of 136 miles of streams was recorded. Major reasons for improvement were improved sewage and industrial waste treatment and a cleanup of 64 miles of the North Branch Susquehanna River which had been reported as degraded in 1980 due to the Butler Tunnel discharge.

A tabulation of stream quality changes (improvements and degradation for the years 1977 through 1981) is summarized in Table 1 (below) by major drainage basin.

Table 1 Pennsylvania Stream Quality (1977-1981)

Drainage Basin	Miles of Streams Improved	Miles of Streams Degraded
Delaware	84	19
Susquehanna	280	152
Ohio	223	281
Lake Erie	3	3
Potomac	1	5
TOTAL	591	410

Summarized in Table 2 below is a status report by drainage basin on compliance with water quality standards. Overall, approximately 79 percent of the State's major streams comply with water quality standards.

Table 2 Compliance with Water Quality Standards

Drainage Basin	Miles of Major Streams	Percent of Major Stream Miles Meeting Standards
Delaware	2,019	75
Susquehanna	6,289	81
Ohio	4,151	76
Lake Erie	105	94
Potomac	418	99
TOTAL	12,962	79

At the present time, 2,744 miles, or approximately 21% of major stream miles in Pennsylvania, fail to meet water quality standards. Abandoned mine drainage, either by itself or in combination with other pollution sources, is responsible for approximately 2,000 of the total miles polluted. Water quality projections to 1983 indicate that 2,406 miles of major streams will fail to meet established "fishable-swimmable" goals. Drainage from abandoned mines, either by itself or in combination with other pollution sources, will account for over 85 percent of the stream miles which are not expected to meet these goals. In addition, the projected lack of federal funds for future municipal treatment projects will hamper clean-up programs.

However, it is apparent from the continuing trend of water quality improvement that progress in attaining the 1983 "fishable-swimmable" goals as set forth in the Clean Water Act is being realized. Improved industrial waste treatment facilities and construction and upgrading of municipal facilities continue to result in improved water quality conditions.

Puerto Rico

For complete copies of the Puerto Rico 305(b) Report, contact:

Environmental Quality Board
1550 Ponce de Leon Avenue
Santurce, PR 00910

Summary

Puerto Rico's worst water quality problem is high fecal coliform counts in a majority of its waters. This problem is caused primarily by overloaded waste treatment facilities combined with poor operation and maintenance of collection, treatment, and disposal facilities. Other contributing factors include lack of adequate wastewater treatment and disposal facilities in many rural communities and for a number of livestock enterprises; industrial noncompliance with NPDES permits; and many illegal dischargers.

Solid waste facilities located near river banks are another problem affecting Puerto Rico's waters. New approaches, coordinated to include the government, industry, and the public, are needed for the management of hazardous and non-hazardous wastes.

A lake study completed under Section 314 of the Clean Water Act showed that of 22 lakes sampled, 18 were eutrophic and 4 were mesotrophic. Restoration of the most important lakes is in doubt due to cuts in the Clean Lakes Program.

In September-October 1981, an islandwide ground water survey was conducted of 57 wells. Major problems found were high salinity in coastal aquifers, the presence of bacteria in water from springs and wells, and contamination by trace organic compounds at selected wells. Main sources for high chloride concentrations seem to be seawater intrusion, concentration of salts from irrigation practices, and residual salts contained in various rock formations.

Rhode Island

For complete copies of the Rhode Island 305(b) Report, contact:

Division of Water Resources
Department of Environmental Management
75 Davis Street
Providence, RI 02908

Summary

This report seeks to summarize existing water quality; current uses of State waters; the difference between current uses and designated uses; and the program costs or other impediments associated with meeting the designated uses. In the discussion of water quality, the basin approach is taken, incorporating basins established for the 303(e) continuing planning process.

As reported in the 1980 305(b) report, significant improvements to water quality have occurred along the Blackstone River with completion of treatment plant projects in Massachusetts and Rhode Island. Within the next few years, depending upon the availability of federal construction grants, significant improvements in water quality will occur along the Pawtuxet River with the upgrading of the Cranston, Warwick, and West Warwick wastewater treatment facilities.

As in other States, the problem of hazardous waste disposal is a major issue in Rhode Island. The Department of Environmental Management and the Department of Health have been working together closely on this problem to prevent environmental damage and insure the continuation of safe surface and ground water supplies.

Existing Conditions

Existing water quality in Rhode Island is summarized by basin in the table below. This information differs from that presented in the past. The major change is that the concept of use attainability is beginning to come into play. Where formerly stream segments were categorized into broad classifications, emphasis is now shifting to site-specific analysis of uses within classifications. Some uses formerly associated with a classification may be deleted for a particular segment.

Rhode Island Water Quality Summary

River Basins/ Estuarine Areas	Total Miles	Miles Meeting Class B	Miles with Impairment of Desig. use	WQ Problems Causing Use Impairment	PS Cause of WQ Problems	NPS Caused WQ Problems
Blackstone R.	88.8	47.9	12.9	2,3	Mu,In	minor
Moosup R.	25.2	25.2	0	-	-	-
Moshassuck R.	17.4	8.2	2	2,3	Mu	major
Pawcatuck R.	115.0	93.9	22.3	3	Mu,In	unknown
Pawtuxet R.	59.7	28.3	17.0	1,2,3	Mu,In	minor
Woonasquatucket R.	22.6	14.3	0	2,3	Mu	major
Total River Miles	328.7	217.8	52.9	-	-	-
Estuarine Areas/Salt Ponds (acres)	117,000	106,000	17,050	3	Mu,In	major

WQ Problems:
1. Harmful substances 2. Oxygen depletion 3. High coliform levels
PS Causes:
MU = municipal sources IN = industrial sources

For example, bathing uses normally associated with Class B waters are impaired in certain areas due to coliform levels. The source of coliforms may be point sources, nonpoint sources, background levels associated with wildlife, or any combination of the three. For these segments, bathing use is impaired, but the general water quality may be well within Class B criteria for other parameters. Moreover, there may be other factors impairing bathing use that were not considered in the classification (channel depths, substrate, velocities, etc.). The Pawcatuck River is by and large the cleanest of the larger rivers in Rhode Island, but has the greatest number of miles with an impairment of a designated use. That use is bathing, and it is impaired by high coliform levels as well as by physical factors. In contrast, the grossly polluted Pawtuxet River has fewer miles with impairment of designated use, but the water quality goals for the Pawtuxet River are lower. Impaired uses of the Pawtuxet River include protection of aquatic life and prevention of nuisance conditions.

South Carolina

For complete copies of the South Carolina 305(b) Report, contact:

South Carolina Department of Health and Environmental Control
Office of Environmental Quality Control
J. Marion Sims Building
2600 Bull Street
Columbia, S.C. 29201

Summary

Of the 88 waters examined with the water quality index (WQI) in this report, six showed 100 percent good quality, 16 showed a mixture of good and fair quality, 56 showed 100 percent fair quality, one showed a mixture of fair and poor quality, eight showed 100 percent poor quality, and one had insufficent data in Water Year 1981. It should be noted that 62 percent of the State's waters are classified either Class B or Class SC and therefore are not aimed at meeting the swimmable part of the fishable-swimmable 1983 federal goal.

Overall trends for Water Years 1979, 1980, and 1981 using the WQI showed three waters improving in quality, 58 showing no trends in quality, 18 showing a lowering in water quality, and nine with insufficient data to detect a trend. For the majority of the waters (65 percent), the quality appears to be changing little even with increased point source loads to some of these areas.

During the past decade, over 390 million dollars in federal funds were spent in South Carolina for the planning and construction of municipal wastewater treatment facilities. It is anticipated that an additional 27 million dollars will be spent in fiscal year 1982. A sufficient water quality data base for assesment purposes was found for 12 out of the 24 construction grant projects. Of these, eight had significant beneficial water quality changes associated with them. The water quality parameter exhibiting the greatest improvement was fecal coliform bacteria, followed by biochemical oxygen demand and dissolved oxygen.

The Clean Lakes Program was established to identify and classify publicly owned freshwater lakes according to trophic condition and to choose methods to restore lakes where use impairment was found. Forty lakes (16 major lakes and 24 minor lakes) were ranked according to their priority for restoration. Federal funding for Clean Lakes projects has been discontinued and there are no federal monies available for lake restoration efforts. The top five priority major lakes were Lake Greenwood, Lake Moultrie, Lake Marion, Lake Murray, and Lake Hartwell. The top five priority minor lakes were Goose Creek Reservoir, Broadway Lake, Lake Edgar A. Brown, Lake Edwin Johnson, and Lake Warren.

In August 1976, the South Carolina Department of Health and Environmental Control and EPA jointly released an advisory against eating fish from Lake Hartwell and Twelve Mile Creek in Pickens County because of high levels of polychlorinated biphenyls (PCBs). The primary source of PCBs was found to be an electrical capacitor manufacturer near Pickens, South Carolina. The source of the PCB problem has been eliminated. Subsequent analysis showed that the advisory could be lifted in certain portions of the lake; it is now only in effect in the areas above S.C. Highway #24. Since 1976, PCB levels in fish have steadily declined. It is now believed the levels will fall below the tolerance limit sooner than peviously expected.

It is recommended that: EPA continue to fund municipal waste treatment projects which will result in significant improvements in water quality problem areas; EPA expedite the pending BAT/Toxic and BAT/BCT guidelines so planning for needed treatment facilities and permitting of discharges under those categories can proceed; funding to implement the EPA proposed water quality standards regulations be increased; and funding be increased through the 106 program to better support special studies and trend monitoring activities.

South Dakota

For complete copies of the South Dakota 305(b) Report, contact:

South Dakota Department of Water and Natural Resources
Joe Foss Building
Pierre, SD 57501

Summary

Nonpoint source pollution is considered the number one quality problem in South Dakota. The Department of Water and Natural Resources (DWNR) has developed an extensive nonpoint source pollution control program using EPA 208 and 314 funds. Nonpoint source pollution has been attacked on several fronts. At the Statewide level, a nonpoint source pollution priority list has been developed county by county. This priority list is based primarily on the personal knowledge of local individuals and needs further documentation of the extent, nature, and impact of the problems. Various State and national agencies and local conservation districts have worked together to develop an effective nonpoint source pollution control program which includes public and local governmental information dissemination; planning and implementation of nonpoint source pollution control projects for specific problem watersheds; development of soil erosion and sediment control ordinances at the Conservation District level; and an effective tracking program. At present, ten problem watersheds are in the implementation process and four are in the planning stage.

Significant improvements in water quality have been achieved through the construction of new wastewater management facilities. However, many needs must still be addresed. The FY 1980 EPA Needs Survey indicated that the following categories must still be resolved: municipal discharges causing water quality problems; municipal discharges that are causing public health hazards; and municipal discharges that do not meet minimum federal requirements.

The degree of impairment of beneficial uses of South Dakota's streams and rivers due to water pollution ranges from none to severe. The most severe impairment is occurring in the Whitewood Creek/Belle Fourche River/Cheyenne River drainage. The sources of the pollution are mine tailings from more than 100 years of mining activities, current mine discharges, nutrients from municipal wastewater discharges, urban runoff, agricultural runoff, livestock, and wood preservation plants. Severe impairment is also occurring in the lower reaches of the White River, in the Bad River, and in Rapid Creek from Rapid City to the Cheyenne River. The problems in the White River are related primarily to erosion of the Badlands and livestock watering. Lack of flow, livestock watering, and soil erosion are the primary causes of water quality degradation in the Bad River. Lower Rapid Creek is degraded by urban runoff and effluent from the municipal wastewater treatment plant. Landowners along this reach report that livestock and wildlife will not drink the water and that the water causes skin irritation. These problems have not been documented or a possible source determined.

In 1981, DWNR examined lake water quality and produced a priority ranking for lake restoration in South Dakota. One hundred lakes were ranked so that restoration monies would be spent on the projects which would produce the most lake improvement and benefit the most people. Most South Dakota lakes are severely affected by runoff which carries silt and nutrients.

Ground water accounts for 45% of all water use in South Dakota. Usage would be higher but is limited by water quality. Many of the deeper aquifers are unfit for domestic use or irrigation because of high concentrations of dissolved salts. Many of the shallower aquifers are polluted with high concentrations of nitrates. Nitrate contamination is of particular concern in Brookings, Hamlin, and Gregory counties. The two largest sources of ground water pollution in South Dakota are excessive and improper use of agricultural chemicals, especially nitrogen fertilizers, and the leakage of poor quality water from deep aquifers into higher quality shallow aquifers from improperly built and abandoned artesian wells.

In terms of nationwide standards, the water quality of South Dakota's public drinking water supplies is poor. Ground water comprises all or part of the supply for 95% of these facilities. Many of these supplies do not meet the recommended criteria for dissolved solids (70%), chloride (6%), sulfate (53%), iron (37%), manganese (51%), fluoride (8%), nitrate (3%), sodium (80%), and selenium (2%). Trihalomethanes and radiological parameters are also present in some supplies, but the extent of the problem is not known.

Tennessee

For complete copies of the Tennessee 305(b) Report, contact:

Tennessee Department of Public Health
Division of Water Quality Control
621 Cordell Hull Building
Nashville, TN 37219

Summary

An overview of water pollution problems in Tennessee indicates that, in general, the quality of waters in the State is very good. There are no gross pollution problems encompassing lengthy segments of streams; most of the pollution is confined to short segments of streams and is the result of one or two point source discharges. Those areas which suffer pollution from multiple dischargers are mainly the larger metropolitan areas of Chattanooga, the Upper Holston River in the Kingsport area, and to a lesser extent the areas associated with Memphis, Nashville, and Knoxville.

There is a considerable amount of surface mining activity in Tennessee, some of which has a very detrimental affect on water quality. Most problem areas are located in the Upper Cumberland River Basin, the Clinch River Basin, and the Lower Tennessee River Basin, and are largely the result of surface mining for coal in highly acidic geologic strata mountainous areas. Because of the Nation's current energy problems, an increase in strip mining for coal is likely, with an equal increase in water quality problems and environmental degradation. Stronger laws and an expanded enforcement program in this area will be necessary to improve this situation and to prevent further degradation. Another area in the energy field needing increased and careful scrutiny is that of nuclear power plants. Thermal discharges and accidental losses of radioactive materials may threaten water quality and public health.

Eutrophication, though not excessive, is beginning to be a problem at some specific sites across the State. Out of 112 publicly owned lakes in Tennessee, 54 have been designated as having problems with eutrophication.

Evaluation of sampling data from 1980 and 1981 generally shows that there has been little change in water quality in Tennessee. Some parameters, especially suspended solids, pH, iron, and manganese, are in consistent violation of State standards in a few river basins. Many of the watersheds in which violations are found are also where surface mining occurs. However, these problems are not as widespread as that of fecal coliform bacteria. Other parameters showing occasional violations include mercury, lead, copper, and phosphorus. These violations are infrequent and occur in various locations across the State, with no specific trends evident. Parameters which show few, if any, violations are BOD_5, dissolved oxygen, temperature, nitrogen (as nitrates and nitrites) and chromium. There are very little data on organic chemicals, but the need for this data is becoming apparent.

Nonpoint source runoff is the major source of agricultural chemicals appearing in streams in the intensive agricultural areas of Western Tennessee. Because of the erosion of up to one inch of soil per year in areas of Western Tennessee, chlordane, DDT, DDE, and other agricultural chemicals are leached from or are carried with the eroding soil to the State's streams.

Industrial pollution problems have begun to be reduced in recent years due to the National Pollutant Discharge Elimination System delegation from EPA giving the State the authority to permit and require compliance monitoring of industries throughout the State. However, there are still significant problem areas in segments of rivers and streams due to past and present industrial discharges which cannot be ignored, such as the Holston River in Upper East Tennesee, the Wolf River near Memphis, and Chattanooga Creek near Chattanooga.

Texas

For complete copies of the Texas 305(b) Report, contact:

Texas Department of Water Resources
Post Office Box 13087
Austin, TX 78711

Summary

Texas rivers, streams, and lakes are subjected to enormous pressures from industrial, agricultural, and recreational endeavors, as well as from steadily increasing population. The State's population is expected to increase by over 5 million by the year 2000. Even with this growth and increasing water use, the quality of the State's waters has improved significantly. Much of this improvement is directly related to improved wastewater treatment programs by both municipalities and industries. These improvements have been accompanied by significant economic growth activities that are water resource dependent, demonstrating that high levels of water quality and economic activity can and are occurring simultaneously in Texas.

The State of Texas is divided into 23 inland and coastal basins for water quality management and planning purposes. The basins are further divided into 311 stream and coastal segments, comprising 16,115 stream miles. Of the 311 segments, the Department has determined that 242 segments presently comply with all applicable stream standards, or are projected to be compliant following incorporation of best practicable treatment by industry and secondary treatment by municipalities. The remaining 69 segments either do not presently comply with applicable stream standards or will be noncompliant with the imposition of best practicable and secondary treatment facilities. Some of these 69 segments may be in compliance with stream standards, or are projected to be brought into compliance as a result of incorporation of advanced waste treatment/advanced secondary treatment for municipalities or best conventional treatment for industries.

The following table summarizes Texas water quality by stream mile for the past five years.

Statewide Summary of Water Quality	1977	1978	1979	1980	1981
Total stream miles	15,565	15,565	16,107	16,107	16,115
Stream miles that are fishable/ swimmable	11,706	13,649	14,598	14,598	14,606
Additional stream miles expected to be fishable/ swimmable by 1983	866	682	992	992	992
Stream miles not expected to be fishable/ swimmable*	2,992	1,234	458	458	458

*Excludes waterway miles not intended to become fishable/swimmable by 1983

Expanded development of the State's water resources and pressures to satisfy numerous beneficial purposes have created local, regional, and Statewide problems of varying intensity. While surface water quality continues to be a major concern, ground water overdraft and degradation are particularly troublesome because of expanding economic activities that are ground water dependent.

Ground water comprises approximately 70% of the total water used by Texans for domestic, municipal, industrial, and agricultural purposes. A ground water quality monitoring network consisting of some 5,600 observation wells is currently maintained by the Department, with 1,100 wells being sampled annually for the common constituents of natural ground water. Local, regional, and other State and federal agencies are also involved in additional monitoring of the quantity and quality of Texas' ground water resources.

Trust Territory of the Pacific Islands

For complete copies of the Trust Territories of the Pacific Islands 305(b) Report, contact:

Trust Territory Environmental Protection Board
Saipan, Mariana Islands 96950

Summary

The Trust Territory of the Pacific Islands (Micronesia) has a total of 13 identified segments, four of which are fresh surface waters. The quality of water in these segments has either improved, due to the elimination of a number of point and nonpoint sources, or remains in its previous condition.

Urbanization, rapid population growth, substandard housing, incomplete sewer and solid waste disposal systems, nonpoint pollution sources, and a lack of adequate safe drinking water are still serious environmental pollution problems in Micronesia.

Water pollution from municipal sources results in water below the level of existing standards in most of the governmental centers in Micronesia and remains a major public health problem. Micronesia recognizes this problem and is continuing to construct sewer treatment facilities, collection systems, and house connections in all major segments.

Rainfall runoff, poor land management practices, and the prevalence of pit and over-water latrines in urban and rural areas contribute substantially to the largely undefined nonpoint source problem. The implementation and general acceptance of earthmoving permit regulations has tended to reduce this problem from construction causes.

Erosion nevertheless threatens the water quality, ecology, subsistence fishing, and overall productivity of the many lagoons and reefs fringing Micronesia's high population centers.

Although there are numerous observed violations of Trust Territory Water Quality Standards, particularly for bacterial standards, most of these areas can be brought within standards by application of appropriate sewage treatment technology and the necessary sewage collection systems.

There are limited areas adjacent to governmental centers which presently do not support shellfish, fish, and wildlife populations appropriate to the waters. These areas have been subjected to nonpoint source pollution, primarly siltation, resulting from poor construction practices. Recent regulations promulgated by the Trust Territory Environmental Protection Board are bringing some degree of control over these sources. In most instances, natural habitat restoration and recolonization will restore damaged areas to near original productivity and ecological balance.

Utah

For complete copies of the Utah 305(b) Report, contact:

Utah Department of Health
Division of Environmental Health
Bureau of Water Pollution Control
150 West North Temple
P.O. Box 2500
Salt Lake City, UT 84110

Summary

Because Utah is the second driest State in the Nation, it has faced and continues to face unique problems in pollution control. Most streams in Utah have relatively low natural streamflow. These flows are often further reduced by diversions for irrigation, domestic, and industrial uses, and thus can be significantly affected by pollution discharges. Population growth and industrial expansion are placing increasing pressures on water quality/public health protection technology. Water pollution controls must become more efficient because there is increasingly more pollution to control and because the environment's ability to absorb pollution does not increase. New kinds of pollution such as hazardous chemicals, and imminent water quality problems from industrial development and mining of coal, oil shale, tar sand, and uranium, must also be dealt with. However, regardless of the type of pollution, it is obviously less expensive to prevent problems than to pay for their solution after they occur.

The Utah Water Pollution Control Committee (UWPCC) has grouped the waters of the State into classes to protect their beneficial uses and has established numerical standards of water quality parameters for each of these uses. In order to monitor for attainment of these standards, the Bureau of Water Pollution Control has established over 500 active and semi-active stream sampling stations. Of these, 170 have been selected for trend analysis to determine water quality degradation or improvement. This report discusses the findings from those 170 stations.

Point sources present a geographically limited problem and are obviously more significant in highly populated areas. Wastewater treatment facilities concentrated in certain drainages seriously affect receiving streams because of the population loads. The important example is the Jordan River, which flows from south to north through the Salt Lake Valley. Eight municipal treatment facilities are currently in operation treating wastewater from a population of 700,000 and discharging into the Jordan River.

Most remaining water quality problems in Utah result from nonpoint sources rather than point source discharges. Nonpoint sources of pollutants include runoff from natural geologic formations, agriculture, urban areas, hydrologic modification, mining, recreation, construction, and silviculture. Natural sandstone formations in eastern and southern Utah contribute significant amounts of sediments through erosion. Natural deposits of salts, phosphates, fluorides, nitrates, and arsenic also contribute to decreasing water quality in certain areas of the State.

The majority of the total water use in Utah is for agriculture. As a result, this is one of the primary sources of man-induced nonpoint pollution. Diversion of waters for irrigation tends to concentrate salts and solids in stream channels. Also, return flow discharges add salts, nutrients, and sediments from croplands into stream channels. Overland runoff contributes salts and sediments from non-irrigated croplands and coliform bacteria from pasture land.

Utah and EPA designated 23 stream segments in Utah as critical water quality problem areas in fiscal year 1981. Improved data analysis has allowed an updating of that priority list in the 305(b) report. The findings of the two reports complement one another; however, this 305(b) report represents a continuing update of the priority stream segments. The Weber River and its tributaries from the Stoddard diversion to its headwaters is the most impaired stream for its designated uses. Recreational developments, agriculture, and energy exploration in the headwaters of this stream segment are the primary reasons why it is the most impaired. Other segments that remain high on the list (Provo River, Jordan River, Spanish Fork River) are those which are most affected by high population. Nonpoint agricultural sources and salinity problems are the reasons why the other stream segments are on the priority list.

Salinity will remain a problem in Utah because of contributions of dissolved solids from natural runoff and agriculture. The State will continue to pursue salinity control activities in the Colorado River and Sevier River basins.

Vermont

For complete copies of the Vermont 305(b) Report, contact:

Vermont Agency of Environmental Conservation
Department of Water Resources
State Office Building
Montpelier, VT 05602

Summary

Vermont has continued to take positive steps toward achieving the desirable goal of total fishable/swimmable waters. The State has for all practical purposes attained total fishable waters. Also, all waters in the State having a designated water use compatible with swimming are capable of achieving this goal. Obviously, the swimmable goal requires a qualifier of "when and where attainable." The level of coliform bacteriological organisms in flowing waters has continued as a basic water quality problem. Nonpoint runoff originating from agricultural, silvicultural, and urban areas (stormwater and combined sewer overflows) is believed to be essentially responsible for the elevated bacteriological levels. These sources are not currently economically controllable.

Eighty-four percent of Vermont's segmented river miles are presently in compliance with all applicable water quality standards. Waters have been brought into compliance mainly through the upgrading and new construction of municipal wastewater treatment facilities.

Substantial progress has been made by the State in cataloging industrial discharges and their impact on receiving water quality and on municipal treatment facilities (in the case of pretreatment industries). The majority of industrial discharges in Vermont presently employ Best Practicable Treatment Technology.

The water quality of Vermont's streams and lakes has continued to show notable improvement during the past two years. This progress is due primarily to continued wastewater treatment facility upgrading and construction, and to further implementation of identified best management practices for construction, silviculture, and agriculture. Implementation of these best management practices has been to a large degree voluntary. These voluntary efforts have been commendable, but continued implementation will be necessary for further water quality progress.

It is fully recognized that serious potential problems still remain and must be addressed if Vermont's high water quality is to be maintained for future generations. The majority of these problem areas such as hydropower development, acid precipitation, protection of upland streams, and water withdrawals do not have straightforward solutions and will require new and innovative approaches to water quality management. In the face of increasingly limited financial resources, implementation of viable solutions to these complex problems will also be more difficult. Vermont is determined to meet this challenge and to protect and maintain its high quality waters.

Virgin Islands

For complete copies of the 305(b) Report for the Virgin Islands, contact:

Division of Natural Resources Management
Department of Conservation & Cultural Affairs
Charlotte Amalie, St. Thomas VI 00801

Summary

The Virgin Islands are made up of three islands—St. Thomas, St. John, and St. Croix—and approximately 50 smaller uninhabited islands. Monitoring data collected over the years have documented the major water pollution problems in the Territory and the progress toward meeting the goals of the Clean Water Act, as follows:

St. Thomas

- New desalination units on St. Thomas prevent the infiltration and contamination problems which plagued the island's public drinking water supplies before 1981.
- Continuous violations of the territorial and federal drinking water standards for bacteria and turbidity have occurred in the drinking water supplied by the Housing Authority. Plans are underway to install new water treatment systems, although funds are not yet available.
- Significant improvements have been made in the operation of three sewage treatment plants (STPs) in the Turpentine Run watershed during 1980-82. These STPs had been discharging partially treated sewage into aquifer recharge areas.
- All open bays have retained their natural water quality conditions.
- As a result of the completion of the Charlotte Amalie STP, the water quality of the Charlotte Amalie harbor has improved since the early 1970s.
- The major water quality problem on St. Thomas is the steady decline in water quality within the mangrove lagoon. Reasons for this decline are the discharge of partially treated sewage by various STPs, and the elimination of large portions of the mangrove forests because of fill operations and channelization.

St. John

- The ground water resources of this island are considered adequate to serve public needs.
- Stormwater runoff causes some standards violations in Cruz Bay.

St. Croix

- New desalination units were installed on St. Croix in 1981. Past problems with infiltration and contamination have therefore been solved.
- Potential ground water contamination problems exist due to leaks in sewage interceptors. Hydrological investigations are underway.
- Water quality in the Christiansted Harbor has improved with the completion of the St. Croix STP.
- The greatest improvement in water quality has occurred along the island's south shore.
- The water quality of the Altcona lagoon and the Salt River estuary is degraded by sedimentation and stormwater runoff.

Program Needs

The current National Pollutant Discharge Elimination System sets the same effluent criteria regardless of the nature of the receiving waters. The practical and cost-effective approach is to devise different criteria for the oceans, estuaries, and inland waters in tropical U.S. environments.

Virginia

For complete copies of the Virginia 305(b) Report, contact:

Virginia State Water Control Board
P.O. Box 11143
Richmond, VA 23230

Summary

Virginia has nine major river basins with over 27,000 miles of perennial streams and 500 square miles of coastal wetlands and embayments. Water quality is generally excellent except in a relatively few areas of the State, reflecting progress made since the inception of the Virginia Water Control Board in 1946. As a result of its NPDES permit program controlling discharges to the State's waters, Virginia has achieved a reduction in BOD_5 of about 54 percent since 1976, despite a growth in population of about seven percent.

Water Quality Standards Compliance

Virginia has 314 water monitoring stations which are sampled monthly for major water quality parameters. Compliance with water quality standards is discussed for four primary parameters: dissolved oxygen, pH, temperature, and fecal coliform bacteria. Trend data for these constituents are also discussed.

During the reporting period, only 14 percent of monitoring stations had even one monthly sample below the minimum dissolved oxygen standard. The dissolved oxygen level at 76 percent of stations was stable over the last 5-10 years. Stations showing an improving trend outnumbered stations with declining oxygen levels almost two to one.

About half of the stations had at least one pH sample outside the range allowed by the standard. Most pH standard violations were due to natural conditions; only three stations had pH problems directly attributable to pollution. Trend analyses show that pH levels are stable at most stations, but stations with increasing pH outnumbered stations with decreasing pH by about three to one.

Only seven percent of the stations had even one value above the allowable temperature maximum. All temperature standard violations were thought to be natural; none were attributed to point sources.

Fecal coliform bacteria levels exceeded allowable levels at 71 percent of the stations. Counts remained stable at 75 percent of the stations, but stations showing improvement outnumbered stations showing increasing counts by about three to one.

Toxic Pollutant Problem Areas

The Virginia report highlights three areas where toxic pollutants are a problem:

- Seasonal commercial fishing restrictions are in effect for 113 miles of the James River estuary because of contamination by the pesticide Kepone. Sport fishing is allowed.
- On the North Fork Holston River, 81 miles are restricted to catch-and-release fishing due to mercury pollution. Abatement measures are underway.

- A fish consumption Health Advisory is in effect for 102 miles of the South River and the South Fork Shenandoah River due to mercury pollution.

The Virginia State Water Control Board completed an EPA-funded study of 161 lakes in March 1981. The lakes were ranked according to trophic status, size, population served, and other factors.

Virginia has been working jointly with EPA, Maryland, Pennsylvania, and citizen groups over the last five years to administer and direct the Chesapeake Bay Program, a $27 million effort to determine environmental problems in the Bay and recommend strategies to assure its protection. Comprehensive planning and coordination are essential to ensure that development and environmental controls are properly balanced. Proper planning is vital if the Bay is to remain a viable resource to be both enjoyed and utilized by future generations of Virginians.

Washington

For complete copies of the Washington 305(b) Report, contact:

Washington Department of Ecology
Office of Water Programs
Water Quality Management Division
Mail Stop PV-11
Olympia, WA 98504

Summary

This document presents Washington's water quality goal, problems, priorities, problem correction/prevention strategies, and planned water quality management activities for the coming year and beyond.

A tabulation of the number of river and marine water segments by water quality status is presented below.

Number of River and Marine Water Segments by Water Quality Status

	North-west	South-west	Central	Eastern	Total State
Meets Goal	21	34	8	2	65
Insufficient Data	12	21	1	5	39
Will Meet Goal	1	0	0	0	1
Point Source Problems	2	5	0	1	8
Nonpoint Source Problems	11	10	5	4	30
Will Not Meet Goal	5	9	2	11	27
Total	52	79	16	23	170

Five rivers and marine segments have been identified as high priority waters experiencing water quality problems. These are: the Duwamish Waterway and River to the limit of tidal influence; Commencement Bay, including the main and inner bay to the Puyallup River; the inner and outer areas of Grays Harbor; the Yakima River from its mouth to its headwaters; and the Spokane River from its mouth to the Washington/Idaho border. Swimming and fishing uses are among those uses impaired in these waters.

Washington has a long history of effectively regulating point sources of pollution, especially municipal and industrial discharges. The principal vehicle for such regulation has been the waste discharge permit program. Certain financial incentives also have been provided to encourage compliance with permit requirements.

As point source problems have been corrected, more attention has been shifted to nonpoint source problems. A subjective evaluation of the relative significance of the nonpoint source problems resulted in the following priorities:

- Agriculture
  - Irrigated Agriculture
  - Dryland Agriculture
  - Dairy Waste Management
- Silviculture
- On-Site Waste Disposal
- Urban Runoff

Priorities also have been identified for the control of point sources. Priorities for regulating municipal and industrial discharges have been identified through the waste discharge permit and compliance programs. Priorities also have been identified for the cleanup of municipal discharges through the municipal wastewater facilities construction grants program.

West Virginia

For complete copies of the West Virginia 305(b) Report, contact:

West Virginia Department of Natural Resources
Division of Water Resources
1201 Greenbrier St.
Charleston, WV 25300

Summary

This assessment of the water quality of West Virginia streams is derived from information collected between July 1979 and June 1981. It is based upon data obtained from monitoring stations maintained by the West Virginia Division of Water Resources and ORSANCO.

Generally, there have been no changes in water quality in West Virginia in recent years. The parameters which were consistently higher than State criteria were coliform bacteria, iron, and phenols. pH, cadmium, and manganese were continual problems on specific streams but were not as ubiquitous as bacteria and phenols. Heavy metal violations were scattered throughout the State and the report period. Parameters which have remained consistently within State criteria include dissolved oxygen, temperature, and mercury.

High phenolic levels have occurred in the Upper Ohio River during the report period. The water quality standard has often been exceeded. High concentrations have resulted in treatment problems at the Wheeling water treatment plant. Possible sources include facilities in Ohio, Pennsylvania, and West Virginia whose total NPDES permit limitations exceed the river's dilution capability at 7-day, 10-year low flow. Severe problems have resulted from periodic slugs of unknown origin, possibly contaminated ground water, runoff from point and nonpoint sources, spills, dumping, or municipal discharges. Extensive monitoring efforts involving EPA, Ohio, Pennsylvania, West Virginia, and the City of Wheeling have failed to identify a single major source for the problem. It now appears the excessive concentrations are the cumulative result of a number of separate contributions including ground water, active industrial facilities, publicly owned sewage treatment works, and others.

This problem's diverse source and interstate nature make it difficult to address. Some federal oversight is needed to ensure that all involved States initiate corrective measures. The major contributing industrial permits in West Virginia are due for reissuance soon and more stringent effluent restrictions on phenolic discharges may be necessary. An areawide effort has been directed towards better "housekeeping" at plant sites thought to be contributing phenolic materials to the river or ground water. Several more years of effort by the involved States will be necessary to develop, initiate, and obtain significant results from an areawide management effort.

Acid mine drainage from abandoned sources continues to be a severe problem in certain areas of the State. The Divisions of Water Resources and Reclamation are currently working to produce an inventory of these sources and to estimate their acid production. Funds have been established by the Surface Mining Control and Reclamation Act of 1977 to reclaim abandoned mine sites. While water quality improvement is not the highest priority under the Act, it is hoped that these funds can eventually be used for this purpose. The Division of Water Resources has recommended that the Big Sandy Creek drainage in Preston County be considered for reclamation when funds are available.

Wisconsin

For complete copies of the Wisconsin 305(b) Report, contact:

Wisconsin Department of Natural Resources
Box 7921
Madison, WI 53707

Summary

The State of Wisconsin contains almost 15,000 lakes and tens of thousands of river and stream miles. There are three major river systems: the Wisconsin, the Fox, and portions of the Mississippi River. Portions of Lakes Superior and Michigan also fall within Wisconsin's boundaries. These varied resources are abundant, but human use has degraded their quality. The Federal Water Pollution Control Act Amendments of 1972, as amended, and associated State statutes have provided a basis for pollution control programs. Resulting water quality improvements have been substantial.

The monthly monitoring program at 44 sites around the State provides a "snapshot" look at the water quality of rivers over time. The monitoring is not an intensive survey, but documents background water quality and general trends in water quality improvement or degradation. Comparison of 1980-1981 data on concentrations of total phosphorus and suspended solids with 1977-78 data shows an average reduction of one-third. These pollutants typically reflect nonpoint source pollution and indicate declining amounts of polluted runoff. The average concentration of biochemical oxygen demand, which commonly indicates water quality degradation from point sources such as municipalities and industries, has decreased at 75 percent of the sites.

Wisconsin's lakes are degraded by nutrient enrichment or eutrophication. A 1979 classification of a representative sample (1,500) of the lakes showed that over 80 percent have a low to medium degree of eutrophication. Another classification of 3,200 lakes is underway.

Wisconsin's Clean Lakes Program aims to limit degradation of damaged lakes and protect the quality of others. The program has administered almost 25 lake rehabilitation projects around the State. Completed projects have resulted in relatively weed-free open water and greater public use of the lakes.

Wisconsin's ground water is abundant and pure. In the center of the State, however, irrigation practices have resulted in ground water contamination from nitrate fertilizers. Also, the pesticide aldicarb has been detected in 70 of the 383 wells tested in the area. Aldicarb levels considered hazardous by EPA were measured in 20 wells. The State Pesticide Review Board has prohibited aldicarb use in central Wisconsin in 1982.

Water pollution control programs are the basis for water quality improvement in surface waters. These programs carry out Wisconsin's commitment to achieve the 1983 goal of "fishable and swimmable" waters. There were 568 municipal dischargers in 1981. By mid 1982, about 60 percent of these dischargers will be complying with the requirement for them to meet an assigned level of wastewater treatment. By July 1, 1983, a compliance rate over 80 percent is predicted.

Over 125 municipalities have complied with their required level of wastewater treatment by upgrading treatment works under the construction grants program. Prior to 1979, all funding was derived from the federal government. Since 1980, though, the State-established Wisconsin Fund has been the major source of funding. The Fund has granted or allocated over $270 million in the past three years. Federal grants totaled about $65 million during this same time.

Nonpoint source pollution—pollution whose source cannot be traced to a single point—is a serious problem in about half of the State. So far, the pollution control program has centered on critical problem areas in 11 watersheds.

A toxic substances survey of Great Lakes tributaries in Wisconsin showed that excessive amounts of polychlorinated biphenyls (PCBs) occurred in southern Lake Michigan tributaries. Three sources of toxics were identified.

The State phosphate detergent ban expired on June 30, 1982. Attempts have been made to document reductions in phosphorus in surface waters as a result of the ban, enacted in 1979, but the length of the ban was too short to cause a measurable change in river phosphorus levels. The study did show lower levels of phosphorus in wastewater entering municipal treatment plants.

In 1979, precipitation collected in Wisconsin was found to be at least ten times more acid than normal. A research program is being carried out by the State, public utilities, and others to define the potential impact of acid rain.

Wyoming

For complete copies of the Wyoming 305(b) Report, contact:

Wyoming Department of Environmental Quality
Water Quality Division
1111 East Lincolnway
Cheyenne, WY 82002

Summary

The Wyoming Statewide Water Quality Assessment provides a summary of water quality information on significant stream segments, lakes, and ground water aquifers in the State.

Water quality data, inventories, indexes, and assessments indicate a generally high quality of water in the State. For years the State has had a low density population coupled with little industrial development. However, in recent years, a rapidly growing population associated with energy and mineral development has necessitated intensified efforts to protect valuable water resources.

Through a combination of State and federal water quality programs, the Water Quality Division has been able to address and solve a number of water quality problems. Although the solution of existing problems is exceedingly important, the Division will continue to emphasize operation of programs which protect high quality waters from degradation.

This report provides summary information on 40 surface waterbodies which have been designated by the Water Quality Division as priorities. In reviewing the 40 priority segments, it is evident that the problems are diverse, widespread, and in many cases have no simple solution.

In some cases, such as Goose Creek (priority #2) and Clear Creek (priority #16), the problems are caused primarily by point sources which are being addressed through compliance schedules and the construction grants process. However, a number of problems in lakes and stream segments are the result of diffuse nonpoint sources, or combinations of point and nonpoint sources. Additionally, a number of federal agencies may be involved in management of lands in a particular drainage area. In order to address these types of problems, the Division cooperates with other State and federal agencies, and utilizes available resources from a variety of programs to obtain a comprehensive solution.

The ambient ground water quality of the State's aquifers varies tremendously. High concentrations of flouride appear to be the most widespread problem for Wyoming's drinking water aquifers. All basins had some wells showing levels of flouride exceeding primary standards in at least one major aquifer. Selenium is also a fairly widespread problem. It should be emphasized, however, that the problems are local in nature. The source of the selenium and flouride appears to be a natural result of host rock properties and ground water characteristics. Other ground water pollution problems are surfacing throughout the State, resulting primarily from past housekeeping procedures at many industrial facilities.

Overall, however, the State has been fortunate to enjoy generally high quality water resources. Wyoming has not had the severe problems faced by many of the densely populated, heavily industrialized States. It is the goal of the Division to continue to make all efforts to reduce or eliminate current pollution problems where feasible, and to protect high quality waters from degradation.

Over the past 20 years, the growing national concern for protecting the environment has brought about an array of Federal environmental laws providing controls against the pollution of air, land, and water resources. For many environmental experts and Members of Congress, another environmental frontier remains—protecting groundwater. Groundwater constitutes more than 96 percent of all the fresh water in the United States, and over 89 billion gallons of this water is pumped out of the ground each day for a variety of potable, agricultural, and industrial purposes. For many of us—116 million people—groundwater is the primary source of drinking water. Given groundwater's importance, there is increasing concern that the potable groundwater in many locations of the country is, or is being, contaminated by toxic or potentially hazardous chemicals. Because of this perceived threat, the adequacy of existing Federal, State, and local statutes to protect groundwater has been called into question.

With several bills to protect groundwater introduced in the 98th Congress, and with the U.S. Environmental Protection Agency working on a groundwater strategy document, it is clear that this issue has moved from a debate concerning whether groundwater protection is a "gap" in the nation's environmental protection program to a debate over the options to deal with the problem.

DONALD V. FELICIANO
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Protecting Groundwater:

A NEW ENVIRONMENTAL FRONTIER?

Living in a clean environment is more than just a matter of aesthetics. Everything we are is a result of the environment's influence: we are products of the air we breathe, the water we drink, and the land from which we obtain much of our food. As surely as we are affected by the environment around us, we impact on the quality of that environment as well. Identifying environmental protection as an important national issue, Congress has responded during the last 20 years by enacting numerous Federal laws to protect its quality.

About a dozen of these laws are being used to stem much of the pollution that exists or is being created today. Although each statute has limitations, studies indicate that the Nation's environment is cleaner today than it was two decades ago. Despite these efforts, pollution continues to be found, and a growing number of reports show that a relatively unregulated resource is becoming contaminated by toxic or potentially hazardous chemicals, thus raising the question that a "gap" exists in our overall environmental protection effort.

That perceived gap, a new environmental frontier, is groundwater. Nearly 100 quadrillion *(100,000,000,000,000,000)* gallons of water is located underground throughout the United States, 50 percent of which has the potential to be used for drinking water.[1] Every day, we pump *89 billion* gallons of water out of underground reservoirs called "aquifers" for a variety of potable, agricultural, and industrial purposes. For many people—nearly 116 million persons—the most important use of this groundwater is for drinking water purposes—some 15 billion gallons per day.[2]

Although *unseen* by the naked eye, groundwater is an integral part of the overall global environment, and it equally affects and is affected by the air, surface waters, and the land. Likewise, pollutants in each medium have the potential to be translocated to another, including the groundwater.

Evidence is growing that groundwater quality is not being protected effectively. In fact, recent surveys show that groundwater contamination from a variety of natural and man-made sources is increasing. A survey by a House Government Operations subcommittee found evidence that 2,830 wells in 20 States have been contaminated within the past few years. In 1983 alone—and in only seven States—the subcommittee concluded that 1,100 wells have been contaminated, affecting thousands of people.[3]

On a national scale, few data on groundwater contamination exist. Some experts estimate that less than one percent of the Nation's groundwater is currently contaminated.[4] Although such a low value seems encouraging, it still is only an educated guess and must be balanced against estimates that certain areas of the country—specifically New York, New Jersey, and New England—probably have groundwater contamination greater than one percent.[5]

The evidence indicating the growing severity of groundwater contamination has raised questions about the adequacy of the existing Federal and State safeguards to protect groundwater. No Federal laws comprehensively protecting groundwater exist, although six have aspects of groundwater protection. As for State protection of groundwater, only 15 groundwater statutes are known, leaving the bulk of the State protection of groundwater up to an array of general environmental laws of differing emphases.

In response to the evidence that groundwater contamination may pose a threat to public health, several Members of Congress have introduced bills to protect special aquifers or to prevent contaminants from reaching groundwater. At the same time, the Environmental Protection Agency (EPA) has sought to better integrate the existing laws it administers into a groundwater protection strategy, which it hopes will provide a forum through which State groundwater protection can also be coordinated.

A Hodgepodge of State Laws

Until Congress enacted several laws in the 1970s that included groundwater protection concerns, groundwater

Reproduced from Feliciano, Donald V., and John E. Blodgett. Protecting groundwater: a new environmental frontier? Congressional Research Service review, v. 5, Feb. 1984: 14-16.

quality, for the most part, had been under the control of the States. Each State has one or more laws pertaining to groundwater management, as well as basic tort doctrines of negligence and nuisance affording remedies for damages. However, these State laws provide a fragmented control mechanism to protect the resource, and depending on the region of the country, the emphasis of many of these statutes is on groundwater quantity (water rights) and not on groundwater quality.

More specifically, a recent EPA survey of groundwater management by the States and territories shows a confusing network of programs: [6]

> 47 States and territories have more than one agency managing groundwater protection; only 9 have one agency overseeing groundwater;
>
> 41 have general environmental laws that might apply to groundwater; only 15 have specific groundwater statutes;
>
> 32 use surface water quality standards to protect groundwater, and 43 require some form of discharge permits; most standards, however, were developed under the Safe Drinking Water Act for protecting drinking water supplies; and
>
> 22 require permits for users of groundwater, but in many circumstances only of large users—not individual homeowners.

A Jumble of Federal Laws

No single piece of Federal legislation protects groundwater exclusively. Six environmental laws administered by the (EPA) contain aspects of groundwater quality protection (usually related to drinking water), but they overlap in parts, leading to some duplication of effort. Furthermore, these laws are not comprehensive, even when administered to complement the individual State protective efforts.

The *Safe Drinking Water Act* (SDWA) is believed to have the most potential for protecting groundwater because of its mandate to protect public drinking water supplies. Under the SDWA, EPA can:

(1) set maximum contaminant levels for drinking water pollutants;
(2) establish regulations for the underground injection of wastes; and
(3) veto Federal financial assistance to projects that might contaminate sensitive groundwater aquifers that are the sole sources of drinking water.[7]

Critics of the SDWA believe that the Act has failed to protect groundwater because of inadequate implementation. They note that maximum contaminant levels have been set for only ten inorganic ions, six pesticides, three radionuclides, and one each for microbes and turbidity. Another limitation is that the Act covers only public water systems; as such, the private wells used by over 40 million people are unregulated, unless by State and local health codes.

One of the intents for the underground injection control program was to have the States manage their own efforts. So far, however, only ten States have assumed full control over their programs, and seven States have partial programs. EPA has had to administer the full programs in 19 States and partial programs in four more because of States choosing not to manage their programs or failing to do so.[8] The sole source aquifer program also has had limited activity: 11 sole source aquifers have been designated for special protection, and 22 more await EPA's decision.

The *Clean Water Act* included aspects of groundwater protection, but generally it has been interpreted to cover only surface waters. It does, however, afford some measure of groundwater protection through its areawide waste management, water quality standard, and discharge permit system provisions.[9]

The *Resource Conservation and Recovery Act* was enacted to regulate the disposal of municipal solid wastes and hazardous wastes, and its protective authority includes groundwater quality. This Act is primarily prospective, regulating waste handling and disposal at approved sites. But, landfilling of wastes occurred long before the 1976 law passed, and the threat to groundwater from the wastes continues.[10]

The *Comprehensive Environmental Response, Compensation, and Liability Act* fills in the remedial gaps of the Resource Conservation and Recovery Act with respect to existing mismanaged or abandoned landfills. Otherwise known as "Superfund," it authorizes the Federal Government to respond to discharges of hazardous substances, including those from landfills, and to clean up contaminated sites if necessary. Although one of the major concerns in the Superfund law is to prevent groundwater contamination, the speed and direction of EPA's efforts to implement the Act have been highly controversial.[11]

The *Toxic Substances Control Act* and the *Federal Insecticide, Fungicide, and Rodenticide Act* do not explicitly provide for groundwater protection, but ways of using their authorities to protect groundwater are being discussed.[12]

With numerous State and Federal laws affecting the protection of groundwater, the current situation is proving difficult to manage.

Options for Protecting Groundwater

Three general approaches have been proposed to improve groundwater protection:

(1) EPA could administratively integrate existing State and Federal groundwater programs to coordinate a groundwater management strategy;
(2) Congress could amend each environmental act to be more responsive to groundwater protection (perhaps by emphasizing integration of the various statutes);
(3) Congress could enact a groundwater-specific protection law.

Aware of its limitations in groundwater protection for some time, EPA has been attempting to put together a groundwater strategy since 1979. Two versions were almost proposed; one was nullified by a change in administrations, the other was held up by objections from then Interior Secretary James Watt.[13]

The latest version, under development since the summer of 1983, is expected to be proposed in early 1984. EPA has ranked the development of a groundwater strategy as its number 8 priority for 1984. EPA's effort is expected to focus on:

(1) the role of the States;
(2) unaddressed groundwater problems, such as leaking underground storage tanks and surface impoundments of hazardous wastes;
(3) framing an agency policy around existing laws; and,
(4) improving EPA internal organization to better manage groundwater, with EPA officials expected to create a groundwater office within the Office of Water.

EPA's pending groundwater strategy revolves around the establishment of criteria and levels of protection for groundwater aquifers, based on their potential usage as sources of drinking water:

(1) special aquifers, such as sole sources;
(2) aquifers that are current or potential sources of drinking water; and
(3) aquifers that are not potential sources of drinking water.

Special aquifers would receive a high level of protection; aquifers that are not potential sources of drinking water would not.

The *second* option—amending each environmental act to better accommodate groundwater protection—has received active consideration during the 98th and prior Congresses. Several bills in the House and Senate have sought to improve groundwater protection concerns in the Safe Drinking Water Act and the Resource Conservation and Recovery Act.

For example, the House passed amendments to the Resource Conservation and Recovery Act (H.R. 2867) on November 3, 1983, which included banning underground injection of hazardous wastes into or above groundwater aquifers that are sources of drinking water and establishing a National Groundwater Commission to study the contamination problem. Groundwater contamination hearings during the 98th Congress have been held by the House Energy and Commerce and Government Operations Committees and the Senate Environment and Public Works Committee. Applying existing laws to address emerging groundwater problems is also being discussed; for example, Senator David Durenberger (R.-Minn.) has expressed interest in using the Toxic Substances Control Act to regulate underground storage tanks that may leak into groundwater.

The *third* option—enacting a separate groundwater protection law—has received congressional interest, but no bill has yet been introduced. Some contend that an additional Federal law specific to groundwater might further interfere with EPA's attempts to coordinate existing laws involving groundwater.

The Administration and some Members of Congress are seeking ways to integrate groundwater protection into the national environmental protection program and thus close a perceived "gap" in the Nation's pollution control effort. The characteristics of a groundwater program remain unsettled, however, including the extent to which new statutory authority is needed. A strong EPA strategy document backed by program activity might forestall Congress writing requirements into law; but already Congress is taking action, not only in oversight, but also in proposing amendments and legislation.

Beyond the immediate issue of protecting groundwater as a specific medium is the basic question of how the nation's environmental statutes work together. The emerging groundwater contamination problem indicates that the environmental protection statutes may not effectively deal with multimedia problems. EPA's response to the groundwater challenge is testing whether administrative action can make the acts work together. Otherwise, groundwater protection may be only one more step in the construction of a national environmental protection program.

However groundwater protection programs may evolve—through legislative or administrative change—there is a growing perception that integrating groundwater into the national environmental protection program is necessary to close a "gap" in the Nation's pollution control effort. At the same time, the effort highlights a basic issue of national environmental policy. Experience has shown that the cheapest repository for waste products is usually the least regulated medium—in this case, groundwater. As the regulation of waste disposal into the air, lakes and rivers, ocean, and land became increasingly strict, the threat to groundwater likely increased in part because its quality was not afforded equal protection.

Despite the use of a "medium by medium" approach to protect the air, lakes and rivers, ocean, and land, such an approach may not be sufficient to protect groundwater. As part of the hydrologic cycle, groundwater picks up pollutants from the air, lakes and rivers, ocean, and land; thus, treating groundwater as a "medium" may not be enough, because contamination of the resource is a multi-media problem. If it is a multi-media problem, perhaps it may need a multi-media solution.

For some, a final environmental frontier may lie in the coherence of the Nation's management of its waste load. Several existing laws make tentative gestures toward such a policy, but these have been interpreted mainly as goals rather than regulatory requirements. If the Nation's waste load can be reduced, it stands to reason that less waste will need to be disposed of in the air, water, or land. Perhaps the lesson of groundwater contamination will lead the Nation to the next logical approach to environmental protection—preventing pollution from occurring in the first place—the ultimate goal of our environmental effort.

Donald V. Feliciano and John E. Blodgett are analyst in environmental policy and specialist in environmental policy, respectively, Environment and Natural Resources Policy Division.

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[7] Safe Drinking Water, by Donald V. Feliciano and Claudia Copeland (continuously updated). Issue Brief 83006.

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[9] Water Quality: Implementing the Clean Water Act, by Claudia Copeland (continuously updated). Issue Brief 83030.

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[11] Superfund: Hazardous Waste Cleanup, by Mark E. Anthony Reisch (continuously updated). Issue Brief 83064.

[12] Groundwater Contamination Through Application of Pesticides: Existing Federal Controls. CRS Typed Report, by George Costello, January 21, 1983. 15 p.

[13] Comparison of the U.S. Environmental Protection Agency's Groundwater Protection Strategies: Carter Administration Version Versus Reagan Administration Version. CRS Typed Report, by Donald V. Feliciano, June 9, 1983. 11 p.

See also these GAO reports: "Waste Disposal Practices—A Threat to Health and the Nation's Water Supply," CED-78-120, June 16, 1978; "Interim Report on Inspection, Enforcement, and Permitting Activities at Hazardous Waste Facilities," GAO/RCED-83-241, Sept. 21, 1983, and Information on Disposal Practices of Generators of Small Quantities of Hazardous Wastes, RCED-83-200, 9-23-83; Cleaning up the Environment: Progress Achieved but Major Unresolved Issues Remain, CED-82-72, 7-21-82.

PROTECTING THE NATION'S GROUNDWATER FROM CONTAMINATION: SUMMARY

Congress of the United States
Office of Technology Assessment
Washington, D.C.

Foreword

Contamination of groundwater is the focus of public attention nationwide—it is being detected with increasing frequency, it has been detected in every State and often near heavily populated areas, and it is linked to adverse health, economic, environmental, and social impacts. At the same time, groundwater is being increasingly relied on for many types of uses and currently supplies the Nation with one-half of its drinking water. The sense of public urgency is reflected in the hearings and debates of the 98th Congress to reauthorize major environmental laws including the Resource Conservation and Recovery Act, the Safe Drinking Water Act, the Clean Water Act, and the Comprehensive Environmental Response, Compensation, and Liability Act ("Superfund").

The objective of the OTA study, as requested by the Senate Committee on Environment and Public Works, is to assess the current status of the Nation's knowledge about and experience in dealing with groundwater contamination problems. Overall, the study shows that much information is available about sources of contamination, impacts, and technologies to guide national policy. In particular, the analysis indicates that, despite the establishment and expansion of numerous Federal and State programs in recent years, these efforts have a narrow focus from a groundwater perspective and, consequently, are limited in their ability to protect groundwater quality.

In order to provide timely input to the requesting committee, the scope of the study was confined to dealing with *existing* contamination problems. The rationale for this choice was the absence of a coherent technical foundation for understanding—i.e., integrating, analyzing, and interpreting—information about the problems caused by groundwater contamination from a national policy perspective. At the same time, OTA recognized that the prevention of *future* contamination would also need to be explicitly considered in order to develop a policy framework for comprehensive resource protection; for example, as experience with hazardous wastes has shown, the cost to clean up contamination can be *enormously* greater than the cost to prevent contamination. Thus, the structure of the study evolved around the concept of *protecting* groundwater quality—comprised of activities to detect, correct, and prevent groundwater contamination—even though the details focus on the detection and correction of existing problems.

Many individual topics related to groundwater contamination, such as prevention alternatives, the effects of specific sources on groundwater contamination, and the effectiveness of specific laws and programs have been explored in greater detail in other OTA studies. Interested readers are referred to, among others, *Assessment of Technologies for Determining Cancer Risks From the Environment* (June 1981), *Use of Models for Water Resources Management, Planning, and Policy* (August 1982), *Technologies and Management Strategies for Hazardous Waste Control* (March 1983), *The Information Content of Premanufacture Notices—A Background Paper* (April 1983), *Water-Related Technologies for Sustainable Agriculture in U.S. Arid* *and Semiarid Lands* (October 1983), *Managing Commercial High-Level Radioactive Waste* (in press), *Cleanup of Uncontrolled Hazardous Waste Sites Under Superfund* (in progress), and *Hazardous Materials Transportation: Technology Issues* (in progress).

The viewpoints of the private sector, environmental groups, academia, the technical community, and public interest organizations were sought in conducting the study. In addition, over two dozen Federal agencies and offices were contacted for the analysis of Federal laws and programs, and each of the States responded to the OTA State survey. OTA thanks the numerous people—advisory panel members, reviewers, advisors, and consultants—who gave so generously of their time and expertise in support of the study. As with all OTA studies, the content of the report is the sole responsibility of OTA.

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NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The views expressed in this OTA report, however, are the sole responsibility of the Office of Technology Assessment.

Protecting the Nation's Groundwater From Contamination

OVERVIEW

Contamination of groundwater—by organic and inorganic chemicals, radionuclides, and/or micro-organisms—has occurred in every State and is being detected with increasing frequency. For a long time, the land surface and subsurface were considered safe and convenient depositories for many of society's wastes and non-waste products. Only recently has the limited capacity of natural soil processes to change contaminants into harmless substances, before they reach groundwater, become widely recognized.

Detailed quantitative estimates of the nationwide extent and effects of groundwater contamination are not now, and probably never will be, available. The time, costs, and technical requirements to develop nationwide estimates would be prohibitive. In addition, information necessary for predicting future contamination problems—about future uses of groundwater, potential sources, and types of contaminants—cannot be known with certainty.

Contaminants found in groundwater—particularly organic chemicals—are associated with adverse health, social, environmental, and economic impacts. **Although only a small portion of the Nation's total groundwater resource is thought to be contaminated, the potential effects of this contamination are significant and warrant national attention.**

Public health concerns arise because some contaminants are individually linked to cancers, liver and kidney damage, and damage to the central nervous system. They also arise because information is not available about the health impacts of many other individual contaminants, or of mixtures of contaminants as typically found in groundwater. Uncertainties about human health impacts are likely to persist because impacts are difficult to study; for example, impacts may not be observable until long after exposure.

Social impacts are often related to anxiety and fear about exposure to contaminants. Exposure can occur unknowingly because even if groundwater is contaminated, it may be odorless, colorless, and tasteless. Exposure can also occur over many years and in many ways—by drinking, eating, bathing, and breathing.

Environmental impacts include the quality degradation of not only soil, but also air and surface water because of interrelationships among environmental media (e.g., groundwater can provide baseflow to streams). Vegetation, fish, and wildlife can be affected adversely.

The economic costs of detecting, correcting, and preventing groundwater contamination at even a single site are high; for example, corrective action can be tens of millions of dollars or more. Economic losses that occur from impaired groundwater quality include decreases in agricultural and industrial productivity, lowered property values, the costs for repair or replacement of damaged equipment and materials, and the costs of developing alternative water supplies.

Adverse impacts from groundwater contamination are likely to increase. Contaminated groundwater is often located near industrialized, heavily populated areas, which increases the likelihood of human exposure. Groundwater is also increasingly relied on as a source of water for many uses; withdrawals for all uses increased from about 35 billion gallons per day in 1950 to almost 90 billion gallons per day in 1980. Groundwater is now a source of drinking water for approximately one-half the Nation's population. It also fills about 40 percent of the Nation's irrigation requirements, about 80 percent of rural requirements both in the home and for livestock, and about 25 percent of self-supplied industrial purposes (other than hydroelectric power).

Current information about the Nation's groundwater contamination problems may not describe the actual situation as much as it reflects the way in which investigations are conducted—which contaminants have been looked for, where they have been looked for, and where they have been found. Because substances found as contaminants in groundwater are used throughout society, more widespread detection of contamination can be expected as efforts increase to monitor known problems, locate as yet undetected problems, and monitor potential problems. Known sources of contamination include not only the commonly recognized point sources associated with hazardous wastes (as defined by Federal statutes) but also non-point sources and sources associated with non-hazardous wastes and non-waste products.

Examples that reflect the diversity of known sources of contamination include: injection wells and septic tanks, which are designed to discharge potential contaminants into the ground; storage tanks and landfills, which are designed to store, treat, and/or dispose of potential contaminants; pipelines and transfer operations, which transport potential contaminants; agricultural practices, which include pesticide and fertilizer applications; production wells, which provide a conduit for potential contaminants to enter groundwater; and salt-water intrusion, which can be induced or worsened by human activities.

Groundwater contamination problems will continue, and probably increase, as long as there are sources, contaminants, and users not being addressed. **Despite the paucity of quantitative details, sufficient information is available about the nature of groundwater contamination to justify national action to protect groundwater quality—defined in this study to be comprised of activities to *detect, correct,* and *prevent* contamination—in order to minimize associated adverse impacts. Policy options generally relate to the development and implementation of Federal and State protection programs and include a broadening of programs to those sources, contaminants, and users not now covered and the provision of adequate and sustained Federal sup-**

port to the States. Unfortunately, the costs and technical uncertainties associated with detection and correction activities effectively preclude the investigation and correction of all known and/or suspected contamination problems. Therefore, prevention is central to any long-term approach to groundwater quality protection. In general, choices among detection, correction, and prevention activities—given limited funds and technical capabilities—will depend on policy decisions regarding which and to what extent groundwater resources will be protected.

FEDERAL AND STATE APPROACH TO GROUNDWATER QUALITY PROTECTION

Numerous Federal and State programs for protecting groundwater quality—for detecting, correcting, and preventing contamination—have been established and expanded in recent years. These efforts have made a significant contribution to the protection of groundwater. For example, sources of contamination have been identified, inventories of selected sources have been conducted, numerous incidents have been documented, and scientific advances have been made in understanding groundwater flow.

At the Federal level, at least 16 statutes authorize programs relevant to groundwater protection, and more than two dozen agencies and offices are involved in groundwater-related activities. All 50 States are concerned about contamination and have programs, at varying stages of development, to protect groundwater. As many as seven agencies with groundwater responsibilities have been identified in a single State.

Despite growing Federal and State efforts, programs are still limited in their ability to protect against contamination. For example, there is no explicit national legislative mandate to protect groundwater quality; and although the groundwater protection strategy of the U.S. Environmental Protection Agency acknowledges the need for comprehensive resource management, the details of the strategy do not fully provide for it. Most authorized programs are in their early stages, and some are at least 10 years from being fully in place. Groundwater quality-related programs among, and within, institutions are often not coordinated, nor are they coordinated with programs for groundwater quantity or surface water even though groundwater and surface water quality and quantity are interconnected.

From a groundwater protection viewpoint, existing Federal and State programs also generally have a narrow focus with respect to sources, contaminants, and users. Essentially, the programs are concerned with managing selected sources of contamination, selected contaminants, and the users of public drinking water supplies.

Narrow Focus on Sources.—Federal and State programs generally focus on managing only selected point sources of contamination, particularly point sources associated with hazardous wastes. **The programs vary in their approaches to protection of groundwater quality and generally do not take into account the potential of the sources to contribute to groundwater contamina-**

Photo credit: State of Florida Department of Environmental Regulation

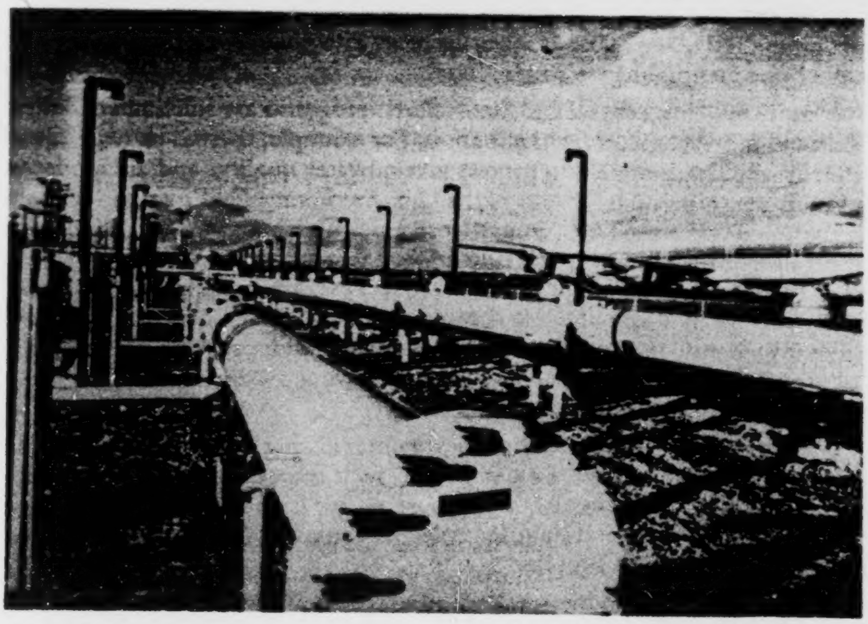

Photo credit: Office of Technology Assessment

Sources of potential groundwater contamination are diverse and include the most commonly addressed point sources associated with hazardous wastes as well as sources associated with non-hazardous wastes (e.g., open dumps, which are usually point in nature and may also contain hazardous wastes) and non-wastes (e.g., product pipelines, which are non-point).

tion. Further, the non-hazardous waste, non-waste, and non-point sources that are known to contaminate groundwater are usually not covered.

Narrow Focus on Contaminants.—This study has documented the detection of over 200 substances—both natural and synthetic—in groundwater. Yet the Federal Government has established only 22 mandatory water quality standards, 18 of which are for specific chemicals. **These Federal standards, developed under the National Interim Primary Drinking Water Regulations of the Safe Drinking Water Act, are inadequate, as substantiated by State responses to the OTA State survey. As a result, many States have set their own standards for drinking water and groundwater quality; both the types of contaminants addressed and the stringency of standards vary from State to State.**

Narrow Focus on Users.—Federal and State programs are directed primarily at the protection of public drinking water supplies. Yet as much as 20 percent of the Nation's population may rely on private wells for drinking water. **The extent to which people relying on private wells are being exposed to groundwater contaminants is unknown, and data are generally not being collected to find out. Data are also unavailable about the impacts of groundwater contamination on non-drinking water uses.**

As a result of the narrow focus of Federal and State programs with respect to groundwater protection in terms of sources, contaminants, and users, related activities to protect against contamination are also narrow in focus. Examples are described below.

Detection Programs

The focus of both inventorying and monitoring efforts is on selected point sources of contamination, primarily on sources of hazardous wastes. Federal inventories of specific sources are limited to surface water impoundments under the Safe Drinking Water Act and to hazardous waste sites and open dumps under the Resource Conservation and Recovery Act. State inventories are directed primarily at sources designed to store, treat, and/or dispose of wastes (e.g., landfills) and at sources designed to discharge potential contaminants into the subsurface (e.g., injection wells). In general, only recently has groundwater monitoring begun to include organic chemicals and trace metals. Routine monitoring is required only for public drinking water supplies, as opposed to private drinking water supplies and supplies for non-drinking water purposes.

Corrective Action Programs

Few corrective actions have been undertaken to date relative to the number of sites identified as requiring such action. For example, although federally funded corrective actions authorized by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as "Superfund") could potentially address a broad range of sources and contaminants, actions thus far have been restricted to primarily hazardous waste sites; in addition, such corrective actions have generally not involved the cleanup of contaminated groundwater. Overall, the provisions of Federal programs for corrective action vary. Two programs establish standards for cleanup (the Resource Conservation and Recovery Act and the Uranium Mill Tailings Radiation Control Act); other programs (e.g., CERCLA) establish cleanup standards on a case-by-case basis.

State corrective action programs are similarly at an early stage of development. The greatest number of State programs relate to spills and accidents and to leaks from storage; other activities tend to be associated with point sources that are designed either to retain (e.g., in landfills) or to discharge (e.g., via injection wells) potential contaminants into the subsurface. Many State corrective actions result from complaints rather than systematic efforts to identify contaminated sites.

Prevention Programs

A limited number of potential sources are addressed in Federal and State programs to prevent groundwater contamination. The programs focus primarily on sources associated with hazardous wastes and other toxic materials. Implementation and enforcement of most program requirements are still in their early stages. Differences among programs have little relationship to the potential for different sources to cause contamination. Current approaches to preventing contamination include provisions for the design, operation, siting, restricted use, and closing of sources. The approaches may be either mandatory or voluntary. Additional approaches to the prevention of groundwater contamination from specific sources include use of alternatives to the contaminating activity (e.g., to land disposal), process or product changes for reduction of waste hazard levels and volumes, and waste recycling and recovery.

A focus on sources is one approach to prevent contamination; other types of approaches have not been widely applied to groundwater. For example, few efforts have been made to control activities located in recharge areas (i.e., portions of a drainage basin that replenish an aquifer). Approaches that are not source-specific are most suitable when there is no single identifiable source or when high volumes of groundwater or large areas are involved (e.g., non-point sources or a clustering of point sources). The Federal Government does provide some support for the protection of *selected* recharge areas through the Sole Source Aquifer Program under the Safe Drinking Water Act; selected recharge areas are also being protected by some States and local governments through land use controls and land acquisition.

Another approach to prevent groundwater contamination is through restrictions on the manufacture or generation, distribution, and use of the contaminating substances themselves. This approach recognizes the fact that any one substance can be released into groundwater from many different sources. To illustrate, pesticides may be introduced from non-point sources such as land application, non-waste sources such as storage tanks, hazardous waste sources such as landfills, and non-hazardous waste sources such as residential disposal.

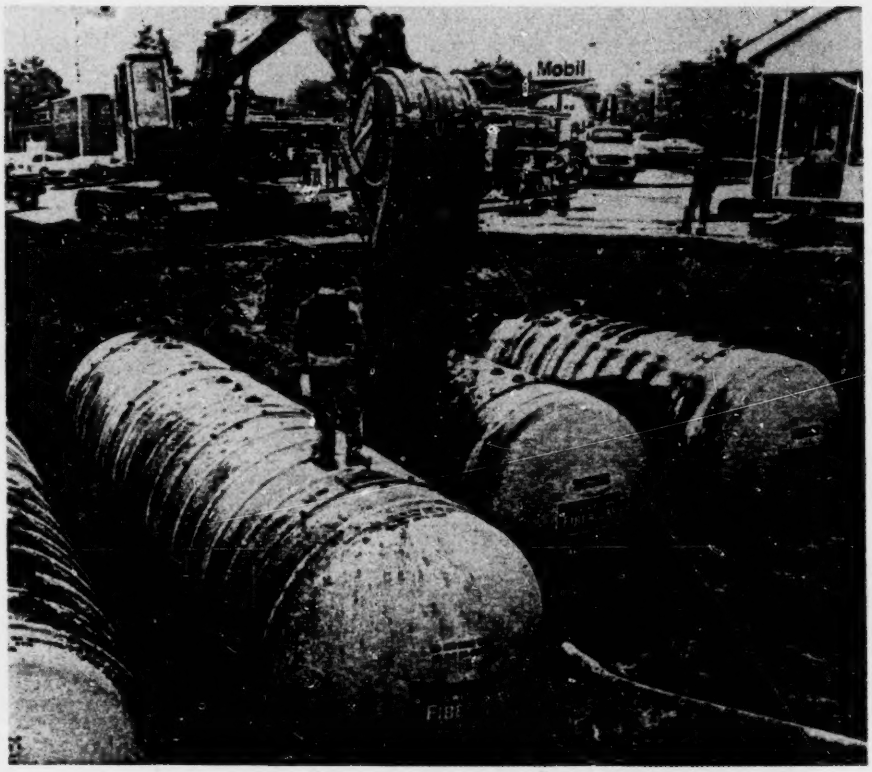

Photo credit: U.S. Environmental Protection Agency

Voluntary replacement of underground gasoline storage tanks is one technique that many States rely on to prevent groundwater contamination.

Although both the Toxic Substances Control Act and the Federal Insecticide, Fungicide, and Rodenticide Act authorize regulation of potential groundwater contaminants, application of associated programs to groundwater has been limited.

TECHNICAL AND NON-TECHNICAL CONSTRAINTS

The effectiveness of Federal and State programs to protect groundwater from contamination has been limited not only by their narrow focus but also by technical and non-technical factors.

Underlying all groundwater protection activities is the hydrogeologic investigation which is used, for example, to detect existing problems, monitor the performance of corrective actions, and monitor the effectiveness of preventive activities. In general, the technologies for obtaining hydrogeologic information are available. Nevertheless, there will always be some degree of uncertainty about contamination because of inherent difficulties in dealing with a phenomenon that is inaccessible to direct observation. Many advances have been made to improve the reliability of results (i.e., to reduce uncertainty), but they often increase the costs and time required to conduct the investigation.

There are major constraints on hydrogeologic investigations in some situations. For example, the technology for conducting reliable investigations in

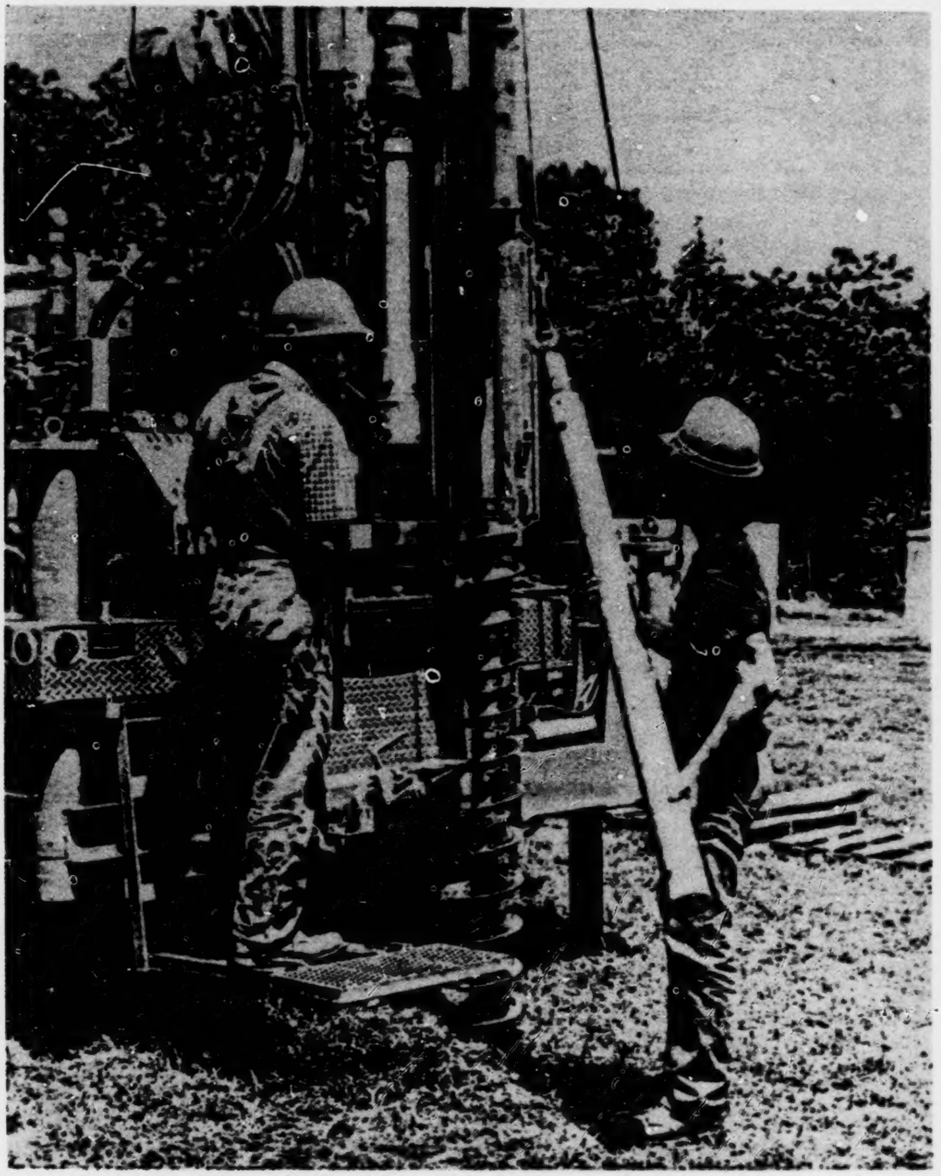

Photo credit: U.S. Environmental Protection Agency

In general, techniques for conducting hydrogeologic investigations are available. Here a drilling rig provides access to undisturbed, uncontaminated samples of a deep aquifer; a hollow-stem auger holds the drilling hole open while a sampling tube is lowered inside and pushed into undisturbed aquifer material.

certain geologic environments such as fractured rock, which occurs throughout the United States, is lacking. Investigations can also be very costly and time-consuming depending on site conditions and the level of detail required by the investigation objectives (e.g., investigations just to *define* a contamination problem could cost anywhere from $25,000 to $500,000 and take many months to complete). In addition, the reliability of a hydrogeologic investigation depends on highly skilled personnel because investigations must be tailored to the site-specific nature of any groundwater contamination problem. Adequately trained personnel are generally in short supply.

Many of the constraints associated with hydrogeologic investigations—costs, time, inadequate supply of trained personnel, and technical uncertainties—also apply to detection, correction, and prevention activities. The importance of the constraints to these activities varies, however, and additional constraints also become relevant.

Detection activities are primarily constrained by the high costs of monitoring. For example, the annual collection and analysis of groundwater quality samples from the 12-14 million private wells in the United States could cost $7 billion or more depending on the techniques used; and such a sampling program would still provide only a snapshot of data, at discrete places and for one point in time, that conveys little information about the sources of any existing contamination or the potential for further or future contamination. One institutional constraint on some States is their lack of authority to obtain data about particular sources of contamination.

Techniques for analyzing groundwater quality samples are biased in terms of which of the contaminants present they detect, and some contaminants cannot be readily measured at low but potentially harmful levels using routinely available methods. Water quality data can also be difficult to analyze and interpret, especially if trace levels or mixtures of contaminants are present or if contaminants have changed chemically and biologically into substances different than those expected.

Major constraints on alternatives for corrective action include: uncertainty about the effectiveness of various techniques to improve groundwater quality; the dependence of technology performance on the amounts of both money and time available; the high costs of taking corrective action of any sort; the need for suitably trained professionals to design and implement measures appropriate for site-specific conditions; and the lack of experience, especially with the large areas or large volumes of contaminated groundwater that are typical of non-point sources. The nature of the contaminants is another constraint; for example, treatment techniques can be costly depending on the contaminants present, and their performance is uncertain when there is a complex mixture of contaminants and/or concentrations change rapidly. Based on experience-to-date, correction alternatives—containment, withdrawal, treatment, in-situ rehabilitation, and management options—appear to be selected according to how rapidly they can be implemented, how rapidly they become effective, the extent to which the uncertainties inherent in their performance can be reduced, and whether there is clear authority to implement the selected strategy.

Institutional constraints on corrective actions relate to ease of access to the site, availability of alternatives for disposal of any contaminants withdrawn or excavated, and ability to implement some correction activities (e.g., withdrawal via pumping) given established water rights. Corrective action can also have environmental side-effects. For example, the management option of closing wells results in the continued presence of and potential for further migration of contaminants, and excavation may transfer contaminants to another site or other environmental media (e.g., surface water and air).

Major constraints on prevention efforts include the lack of funds to implement existing programs, uncertainty about the technical adequacy of available methods and ongoing efforts, and incomplete understanding about the relationship between land use and groundwater quality. Some techniques used to prevent contamination are the same as those used for correction (e.g., containment measures such as liners), so that the same uncertainties about performance are pertinent.

NATIONAL POLICY IMPLICATIONS

National policy options generally relate to the development and implementation of Federal and State groundwater quality protection programs.

The existing Federal statutory framework appears to have the *potential* to protect the Nation's groundwater from further contamination. **However, the realization of this potential will depend on broadening the coverage of authorized programs to those sources, contaminants, and users not presently**

Photo credit: Charles O'Rear

Many States lack adequate authority to deal with agriculturally related sources of groundwater contamination including pesticide and fertilizer applications and agricultural wastes.

included and on effectively implementing programs. Many approaches for broadening and implementing programs are possible, such as mandatory requirements, voluntary procedures, and/or incentives and disincentives. Effective implementation will also require the coordination of activities among and within agencies (e.g., health departments, State geological surveys, and departments of environmental protection) for both groundwater and surface water quality and quantity. Ultimately, groundwater quality protection will also depend on political judgments about both the appropriate role of the Federal Government and the importance of all States making comparable progress in their abilities to detect, correct, and/or prevent groundwater contamination.

Fundamental to the development of any national policy related to the protection of groundwater from contamination is recognition of the site-specific nature of the problems. Efforts to detect, correct, and prevent contamination must be tailored to the full range of conditions found at any site, including sources, contaminants, and users. **National policy must be flexible in its ability to respond to and accommodate different groundwater quality problems characterized by varying site conditions.** For example, the choice of appropriate monitoring parameters, locations, and frequencies cannot be rigidly specified apart from site conditions; however, the factors that need to be considered in making this choice could be specified. **A major function of the Federal Government would be to provide adequate and sustained support to the States for detecting, correcting, and preventing groundwater contamination. The principal areas for Federal support to the States that would be the most helpful in achieving groundwater quality protection are funding, technical assistance, and research and development.**

The need for flexibility in national policy is underscored by the vast differences among State approaches to protecting groundwater. States vary in their perception about their contamination problems, priorities among sources and users, capabilities, stages of program development and implementation, and institutional arrangements. Land use considerations, essential for preventing contamination from non-point sources or from clusters of point sources, have traditionally been addressed at the State and local levels.

Current Federal laws and programs have generally helped the States with their groundwater contamination problems. However, based on responses to the OTA State survey, the level of Federal support to the States is not adequate; nor is it directed at all of the States' problems. In some cases, current Federal laws and programs have created problems: surface water quality problems have been reduced at the expense of groundwater quality because Federal programs fail to recognize the interrelationships among environmental media; Federal programs fail to accommodate variations in State conditions; and the lack of an explicit national legislative goal to protect groundwater quality has led to uncoordinated Federal programs and has handicapped the States in obtaining authority to address certain problems.

Funding

Currently no Federal program has earmarked funds specifically for the protection of groundwater quality. In addition, funding for programs that have supported groundwater-related activities has been reduced or eliminated (e.g., funding under Section 208 of the Clean Water Act, for State solid waste programs under Subtitle D of the Resource Conservation and Recovery Act, and for the Rural Abandoned Mine Program under the Surface Mining Control and Reclamation Act). As a result, groundwater and other water quality programs are competing for limited State grants (e.g., under Sections 106 and 205(j) of the Clean Water Act). Because of the high costs associated with groundwater protection, Federal funding assistance is desired by the States for both the development *and* implementation of State initiatives.

Technical Assistance

Technical assistance to the States can include training programs, the development of criteria and/or guidelines, and information exchange.

Qualified personnel are essential for protection activities because activities need to be tailored to site conditions. **The supply of qualified technical per-**

Photo credit: John Gilbert, EPA Environmental Response Team

Training of staff is required for dealing safely and effectively with site-specific groundwater contamination problems.

sonnel appears to be limited and to be an important constraint on the Nation's ability to protect groundwater quality. Federal support for training and education is required for a *rapid* increase in the Nation's technical capabilities. The States have been assisted by the Cooperative Program of the U.S. Geological Survey, and they would like to see it and other technical assistance programs continued. Establishment of professional certification programs or other criteria (e.g., by the Federal Government, the States, or professional societies) for ensuring that personnel possess minimum technical qualifications would also help to develop—and to provide a check in the hiring of—qualified technical manpower.

Although contamination problems require site-specific judgments, they nevertheless have common features that are amenable to the development of Federal criteria and/or guidelines. From a national perspective, the goal of these criteria and/or guidelines would be to ensure that at least a minimum set of considerations is being taken into account for protection of groundwater quality. Further, they would also be an efficient means of providing information required by all States in handling their groundwater contamination problems; for example, general guidelines could be developed for assisting the States in setting priorities for allocating scarce resources among alternative protection activities. In addition to criteria and guidelines, the Federal Government could provide direct assistance to States in specified situations.

Technical assistance could include:

- With respect to detection:
  - — Criteria and/or guidelines to assist the States in conducting reliable hydrogeologic investigations under different site conditions and in addressing, for example, monitoring of the flow system, sampling and analysis, and data interpretation.
  - — Criteria and/or guidelines for addressing contaminants for which there are no Federal standards, including for mixtures. Standards development for these contaminants is also needed (see *Research and Development,* below).
  - — Criteria and/or guidelines to assist the States in setting priorities among sources and in determining which sources they will monitor and inventory.
- With respect to correction:
  - — Criteria and/or guidelines to assist the States in selecting and implementing corrective action under various conditions.
  - — Criteria and/or guidelines for setting cleanup standards on a site-specific basis, incorporating such factors as the limitations and likely performance of technology and current and/or potential users.
- With respect to prevention:
  - — Criteria and/or guidelines for preventing contamination from all potential contaminating sources; for a given source, performance criteria and/or guidelines for addressing its siting, design and operation during its active life, and closure. Alternatives for reducing the wastes generated by a source, and for waste recycling, also need to be considered as part of preventing contamination from sources.

  - Criteria and/or guidelines for considering prevention alternatives apart from those related to specific sources, e.g., for the protection of aquifer recharge areas and for establishing an institutional memory for the locations of sources, contaminants, and land uses.

Because of the complexities of groundwater contamination problems and because efforts to protect groundwater are generally in their early stages, there are several important opportunities for the Federal Government to facilitate information exchange among the States. Information exchange would not necessarily include the details of site-specific case studies; rather, programmatic information about State approaches to protection would assist the States in learning from the successes, and failures, of each other.

Research and Development

Some research and development activities can provide timely information that would support all of the States in their groundwater protection efforts. Key activities include:

- With respect to detection:
  - Research on toxicology and the adverse health effects of contaminants that are being found in groundwater, with particular emphasis on the synergistic effects of mixtures of contaminants.
  - Development of water quality standards for substances known to occur in groundwater that are not now covered; these standards could be applied in State drinking water and groundwater quality programs.
  - Research on assessment of the environmental and economic impacts of contamination.
  - Research on less costly techniques for hydrogeologic investigations in general and development of reliable techniques for conditions that cannot now be addressed adequately (e.g., fractured rock).
- With respect to correction:
  - Research on the behavior of individual contaminants in groundwater and, in particular, on the potential for the chemical and biological transformation of organic chemicals.
  - Research on chemical and biological reactions in fluids that would be necessary, for example, for the development of techniques for treating water with multiple contaminants.
- With respect to prevention:
  - Opportunities and mechanisms for preventing contamination, including ways of reducing the generation (e.g., by process or product changes) and disposal (e.g., through resource recovery and recycling) of potential contaminants.

Ultimately, the protection of groundwater from contamination will also depend on raising the consciousness of the public as has been done for littering and air and surface water pollution. All segments of society need to understand how their activities affect groundwater quality and, in turn, how they may be affected. Public confidence will grow only as timely efforts are made to detect, correct, and prevent groundwater contamination from all sources and contaminants, to protect all of the public's interests.

Illustration credit: Sacramento County, CA

Some communities have implemented household hazardous waste collection programs as part of their efforts to protect groundwater quality.

NOTE: Copies of the full report "Protecting the Nation's Groundwater From Contamination" can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, GPO stock No. 052-003-00966-8.

United States
Environmental Protection
Agency

Office of
Ground-Water Protection
Washington, DC 20460

August 1984

Water

EPA

Ground-Water Protection Strategy

A GROUND-WATER PROTECTION STRATEGY

FOR THE

ENVIRONMENTAL PROTECTION AGENCY

AUGUST 1984

GROUND-WATER PROTECTION STRATEGY

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EXECUTIVE SUMMARY

In the last decade the public has grown increasingly aware of the potential problem of ground-water contamination. Reports of chemicals threatening drinking water supplies have mobilized State, local and Federal governments to respond. But these responses suffer from a lack of coordination among responsible agencies, limited information about the health effects of exposure to some contaminants, and a limited scientific foundation on which to base policy decisions.

Officials at all levels of government have begun to look for a definable strategy to protect ground water. The strategy presented here will provide a common reference for responsible institutions as they work toward the shared goal of preserving, for current and future generations, clean ground water for drinking and other uses, while protecting the public health of citizens who may be exposed to the effects of past contamination.

EPA Administrator William D. Ruckelshaus recognized the need to protect ground-water quality as a national concern. In response, Deputy Administrator Alvin L. Alm formed a Ground-Water Task Force to: (1) identify areas of serious inconsistencies among programs and institutions at the State, local and Federal levels; (2) assess the need for greater program coordination within EPA; and (3) help strengthen States' capabilities to protect ground-water resources as they themselves define the need. In line with EPA's mission to preserve and enhance environmental quality, this strategy document focuses on issues of ground-water quality.

(Issues of water quantity and allocation are also important, but they are outside the province of EPA. Many ground-water quality issues (for example, salt-water intrusion) are closely related to issues of ground-water quantity and allocation. States will have to approach such issues through integrated policies; topics relating primarily to quantity and allocation are not addressed in this document. With respect to EPA activities the scope and intent of this document includes only EPA's statutory and regulatory authority.)

The Task Force was composed of staff from each affected EPA Program Office and two EPA regions. The Office of Water chaired the group. Beginning work in June 1983, the Task Force delivered a draft report to the Deputy Administrator on September 1, 1983. He sought the views of senior Agency policy-makers by meeting with the involved Assistant Administrators and their key staff on many occasions to discuss the report and its implications.

As options began to narrow, this senior policy group requested additional analyses from the Task Force, consulting with Regional Administrators as it proceeded. At length, after concerted debate and broad-scale Agency involvement, the main policy elements for an EPA Ground-Water Protection Strategy emerged. Draft conclusions were discussed with Congressional staff, State organizations, and environmental and industry organizations.

A draft strategy resulting from that decision process was then distributed to State officials and to select State, business and industry, and environmental organizations for comment. Approximately 150 organizations submitted comments. After receiving comments from these interested parties, EPA revised the draft strategy for final consideration by the Deputy Administrator and Assistant Administrators. This final Ground-Water Protection Strategy is the product of that deliberation process.

A Perspective on Ground Water

In the 1970's, national environmental concern focused mainly on natural resources and pollutants we could see or smell. Surface water and air quality, specific types of contaminants such as pesticides, or obvious sources of contamination such as uncontrolled hazardous waste sites, were of primary concern. People concerned themselves only rarely with ground water since, hidden from view as it is, few knew or really understood how seriously the resource was being compromised.

Today, ground-water contamination looms as a major environmental issue of the 1980's. The attention of agencies at all levels of government, as well as that of industry and environmentalists, is now focused on this vital resource. As contamination has appeared in well water and wells have been closed, the public has expressed growing concern about the health implications of inappropriate use and disposal of chemicals. As concern has increased, so have demands for expanded protection of the resource.

Our understanding of the sources and dimension of the threat is limited, but increasing. Scientists can now measure specific organic chemicals at the parts-per-billion or -trillion levels. As new health studies are completed and as we learn more about various sources of ground-water contamination, our capacity to deal with this problem increases. Scientists and engineers have also learned more about how contaminants move in the subsurface -- which ones bind to soils and which ones pass through to the water table beneath. They are now identifying technologies to prevent, control, and clean up ground-water contamination.

Major Authorities and Responsibilities

The Task Force reviewed EPA's statutory authority as it relates to ground water and examined the current scope and extent of State programs as well. While the nature and variability of ground water makes its management the primary responsibility of States, the Task Force found that a number of Federal authorities exist to support States in the effort.

Since these Federal statutes were enacted at various times for separate purposes, inconsistency developed in EPA's regulations and in the decisions made under them. While these differences are often necessary and reasonable, there are a number that appear to hinder a cohesive approach to ground-water protection. Improving harmony among EPA's program rules affecting ground-water protection is an important need, since inconsistency in such matters leads to confusion and less effective protection than if roles, requirements, and responsibilities are clear and consistent.

In addition to its own authorities, EPA found a variety of powerful State and local statutes available for use. A number of States have begun their own programs for ground-water protection, some built on permits supported by a system of aquifer classification. Continuing the development of State programs in this area is vital, as they have the basic responsibility for the protection of the ground-water resource.

Strategic Concerns

Given public concerns, EPA, as well as State and local governmental agencies, must decide how best to protect public health and critical environmental systems. It seems clear to many that we must direct our energies to minimize future contamination, even as we detect and manage contamination associated with past activities.

Protecting ground water will be difficult. Starting with limited knowledge of the resource and limited means to address existing or potential problems, we must expend our efforts where groundwater contamination would cause the greatest harm. Consequently, we assign highest priority to those ground waters that are currently used as sources of drinking water or that feed and replenish unique ecosystems.

Ground-water protection is a very complex and difficult issue. It will require sustained effort at all levels of government over a long period of time before this resource will be adequately protected. Within this context, EPA developed its Ground-Water Protection Strategy.

EPA's Ground-Water Protection Strategy

The EPA Strategy includes four major components that address critical needs. They are:

- Short-term build-up of institutions at the State level;
- Assessing the problems that may exist from unaddressed sources of contamination--in particular, leaking storage tanks, surface impoundments, and landfills;
- Issuing guidelines for EPA decisions affecting ground-water protection and cleanup; and
- Strengthening EPA's organization for ground-water management at the Headquarters and Regional levels, and strengthening EPA's cooperation with Federal and State agencies.

These components, described in detail in Chapter IV, are summarized below.

EPA will provide support to States for program development and institution building. EPA will encourage States to make use of certain existing grant programs to develop ground-water protection programs and strategies. These funds will support necessary program development and planning, the creation of needed data systems, assessment of legal and institutional impediments to comprehensive State management, and the development of State regulatory programs such as permitting and classification. Regional Administrators will work with Governors so that funds are directed to the State agency or programs with the most complete authority and capability to undertake or continue statewide program or strategy development. EPA will also provide State agencies with technical assistance in solving ground-water problems and will continue to support a strong research program in ground water.

EPA will address contamination from underground storage tanks. Because the evidence suggests that leaking storage tanks--particulary from gasoline--may represent a major, unaddressed source of ground-water contamination, the Deputy Administrator has directed the Office of Toxic Substances to design a study to identify the nature, extent, and severity of the problem. EPA is investigating the application of the Toxic Substances Control Act (TSCA), as well as other authorities, as a potential legal basis for applying appropriate requirements on design and operation of these tanks. In the meantime, the Agency will issue chemical advisories to alert owners and operators about the problem and work with States and industry to develop voluntary steps to reduce contamination. EPA is also planning direct regulation of underground storage of hazardous waste under the Resource Conservation and Recovery Act (RCRA).

EPA will study the need for further regulation of land disposal facilities, including surface impoundments and landfills. EPA, in cooperation with the States, will conduct studies of impoundments and landfills as to the degree of danger they present, set priorities for control, review the regulatory options available, and determine if additional Federal controls are needed.

EPA will adopt guidelines for consistency in its ground-water protection programs. The guidelines will be based on the policy that ground-water protection should consider the highest beneficial use to which ground water having significant water resources value can presently or potentially be put. Under this policy, the guidelines define protection policies for three classes of ground water, based on their respective value and their vulnerability to contamination. These guidelines are intended to provide a framework for the decisions that EPA and States will have to make in implementing EPA programs. The guidelines will be used by EPA and the States to make decisions on levels of protection and cleanup under existing regulations, to guide future regulations, and to establish enforcement priorities for the future. (These regulations will then provide the legal basis for the implementation of the guidelines. It is not intended that any substantive or procedural rights are provided by this Strategy.)

The classes of ground water are as follows:

Class I: Special Ground Waters are those that are highly vulnerable to contamination because of the hydrological characteristics of the areas under which they occur and that are also characterized by either of the following two factors:

a) Irreplaceable, in that no reasonable alternative source of drinking water is available to substantial populations; or

b) Ecologically vital, in that the aquifer provides the base flow for a particularly sensitive ecological system that, if polluted, would destroy a unique habitat.

Class II: Current and Potential Sources of Drinking Water and Waters Having Other Beneficial Uses are all other ground waters that are currently used or are potentially available for drinking water or other beneficial use.

Class III: Ground Waters Not Considered Potential Sources of Drinking Water and of Limited Beneficial Use are ground waters that are heavily saline, with Total Dissolved Solids (TDS) levels over 10,000 mg/L), or are otherwise contaminated beyond levels that allow cleanup using methods reasonably employed in public water system treatment. These ground waters also must not migrate to Class I or II ground waters or have a discharge to surface water that could cause degradation.

EPA will accord different levels of protection to each class as described in the examples below. Chapter IV describes in more detail the regulatory approaches EPA will take to protect these ground-water classes under each statute.

To prevent contamination of Class I ground waters EPA will initially discourage by guidance, and eventually ban by regulation, the siting of new hazardous waste land disposal facilities over Special Ground Waters. Some restrictions may also be applied to existing land disposal facilities. Further, Agency policy will be directed toward restricting or banning the use in these areas of those pesticides which are known to leach through soils and are a particular problem in ground water. EPA's general policy for cleanup of contamination will be the most stringent in these areas, involving cleanup to background or drinking water levels.

Ground waters that are current and potential sources of drinking water (Class II) will receive levels of protection consistent with those now provided for ground water under EPA's existing regulations. In addition, where ground waters are vulnerable to contamination and used as a current source of drinking water, EPA may ban the siting of new hazardous waste land disposal facilities, initially through guidance, and later through regulation. While EPA's cleanup policy will assure drinking water quality or background levels, exemptions will be available to allow a less stringent level under certain circumstances wher protection of human health and the environment can be demonstrated. EPA may establish some differences in cleanup depending on whether the ground water is used as a current or potential source of drinking water or for other beneficial purposes.

Ground waters that are not considered potential sources of drinking water and have limited beneficial use (Class III) will receive less protection than Class I or II. Technology standards for hazardous waste facilities generally would be the same as for Class I and Class II. With respect to cleanup, should the hazardous waste facility leak, waivers establishing less stringent concentration limits would be considered on a case-by-case basis. Waivers would not be available, however, when a facility caused the contamination that precluded future use. EPA's Superfund program will not focus its activities on protecting or improving ground water that has no potential impact on human health and the environment.

To improve the consistency and effectiveness of EPA's current ground-water programs, the guidelines will be incorporated into each of the Agency's relevant program areas. Many of these programs are delegated to the States, and for most programs, States must demonstrate that their programs are "no less stringent" than the Federal program in order to qualify for authorization to implement the programs. However, in implementing these guidelines EPA will provide as much flexibility to the States as is possible under state delegation agreements.

Consequently, EPA will to the extent possible keep regulatory requirements based on EPA's ground-water protection guidelines general and performance-oriented. EPA will, in addition, develop guidance to accompany such regulations for use by EPA when EPA directly administers a program in a State (e.g., implementation in a non-delegated State or implementation of a program which cannot be delegated). Such accompanying guidance would not be binding on the States, but it could also be used by the States to assist them in developing their own regulatory requirements or guidelines. This guidance will, for example, define more precisely the meaning of the terms used in the Strategy, such as "vulnerable and unique habitat".

The task of actually determining whether the ground water in a particular location fits the criteria for Class I, II, or III will be a site-specific determination. In programs involving permits, such as RCRA and Underground Injection Control (UIC), for example, this determination will be made during the permitting process based on data supplied by the permit applicant. In cleanup actions under Comprehensive Environmental Response Compensation and Liability Act (CERCLA), the ground-water class will be determined in conjunction with the assessment of the extent of contamination. Where States have already mapped or designated ground water for that location, the State classification of the ground water will provide useful guidance.

EPA will improve its own institutional capability to protect ground water. EPA has assigned ground-water coordination and development responsibilities to the Assistant Administrator for Water and he has established an Office of Ground-Water Protection to oversee the implementation of this Strategy. The Director of that Office has already started to work with other EPA offices and Regions to institutionalize EPA and State ground-water roles, plan for correction of uncontrolled sources of contamination, identify and resolve inconsistencies among EPA programs, and learn more about the nature and extent of ground-water contamination.

EPA Regional offices are also in the process of establishing Regional ground-water units. They will coordinate Regional ground-water policy and program development and assist the States through grants and technical assistance designed to increase their institutional capabilities to manage ground water.

EPA will carry out this Strategy in partnership with other Federal agencies, especially the Department of Interior (DOI), to insure that the Strategy is implemented as effectively as possible.

The body of this report contains three chapters and an Appendix. Chapter II describes the nature and extent of ground-water contamination. Chapter III describes State and Federal programs for ground-water protection. Chapter IV describes EPA's strategy to protect ground water. The appendices include a matrix describing State, local, and Federal roles and a summary of the options considered by EPA in developing this Strategy.

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THE NATURE AND EXTENT OF GROUND-WATER CONTAMINATION OF THE UNITED STATES

EPA's Task Force on Ground Water examined a number of published and internal technical reports to assess the nature, sources, and extent of ground-water contamination. This chapter presents the findings and conclusions of that review.

Findings

1. THE NATURE OF GROUND WATER

Ground water is a vast resource underlying all of our land. Ground water occurs in aquifers beneath the surface of the earth. Aquifers are geologic formations that contain enough water in a sufficiently permeable setting to yield usable amounts of water to wells and springs. Because of its dimension and because of geologic and geochemical factors that influence its movement and characteristics, it is a very complex resource to understand.

Usable aquifers are present nearly everywhere in the United States. The volume of known ground water is about 50 times greater than annual surface flow in the entire Nation. Another way to conceptualize the immense size of this resource is to consider that the volume of ground water to be found within one-half mile of the surface is estimated to be more than four times that of the Great Lakes.

In general, the degree to which people use ground water depends on a number of factors, one of which is whether good quality surface water is available. Another is the relative cost of delivering the ground water to individual users.

Ground water is the source of a substantial proportion (24 percent) of the Nation's domestic, agricultural, and industrial water. Between 1950 and 1980, total ground-water withdrawals increased from 34 to 89 billion gallons per day (BGD), an increase of 162 percent. The 1980 figure represents 24 percent of all the fresh water used (372 BGD) that year. Further, ground-water withdrawals are projected to reach 100 BGD by 1985. The principal uses of ground water in 1980 were for irrigation (60 BGD), public drinking water (12 BGD), with smaller amounts applied to industrial and rural household use.1/

Reliance on ground water has increased greatly over the past 35 years. In part, this increase is the result of a migration of population during the decade of the 1970's to rural areas, where ground water is more easily accessible than surface water. In some parts of the country ground water is often the only available source of drinking water and can generally be used with little or no treatment.

Once contaminated, ground water presents particularly difficult problems for monitoring and clean-up. In many ways ground water is far more difficult to manage than air or surface water because it is not accessible directly. Ground water is slow-moving, with velocities generally in the range of 5 to 50 feet per year. Large amounts of a contaminant can enter an aquifer and remain undetected until a water well or surface water body is affected. Moreover, contaminants in ground water--unlike those in surface water--generally move in a plume with relatively little mixing or dispersion, so concentrations remain high. These plumes of relatively concentrated contaminants move slowly through the aquifer and are typically present for many years--sometimes for decades or longer--making the resource virtually unusable over periods of time. Although opportunity exists for chemical or biological transformation, changes in the concentrations of contaminants occur slowly so that they may not be readily discernible in the short-term. Because an individual plume may underlie only a very small part of the land surface, it is difficult to detect by aquifer-wide or regional monitoring.

Monitoring of ground water is very expensive, particularly where depths are substantial and multiple test wells must be drilled. Restoration after contamination is often complex and expensive, and success is unpredictable. For example, in the case of a gasoline spill, where the contaminant is valuable, recovery operations are typically 40-60 percent effective at best. In most circumstances it is prudent to protect the resource from contamination in the first place, rather than rely on clean-up after the fact.

Ground-water contamination is of particular concern because of its potential impact on sources of drinking water. Over 50 percent of the U.S. population draws upon ground water for its potable water supply. Approximately 117 million people in the U.S. get their drinking water from ground water supplied by 48,000 community public water systems and approximately 12 million individual wells. The remaining people get their drinking water from 11,000 public water systems drawing from surface water sources. About 95 percent of rural households depend on ground water, as does a still larger proportion (97 percent) of the 165,000 non-community public water supplies (such as camps or restaurants serving a transient population). Finally, 34 of the 100 largest U.S. cities rely completely or partially on ground water.2/

Until recently, the public viewed drinking water drawn from the ground as a pristine resource, unspoiled by human activities. Most believed that soils were capable of binding and holding chemicals applied to their surfaces. While this is true for some chemicals, we have learned over the past few years that it is definitely not true for several important and widely used classes of chemicals, such as low molecular-weight organic solvents. Among those of primary concern are such common chemical solvents as tri- and tetrachloroethylene, benzene, and chlorinated benzenes.

This new understanding of the vulnerability of ground water to contamination by man-made chemicals is significant. Where concentrations of these substances have been encountered in ground water, they have been orders of magnitude higher than those generally found in surface water. This is particularly disturbing because, while about half of water systems drawing from ground water provide chlorination treatment, this is ineffective for chemical contaminants. Only about 6 percent of such systems use treatment which remove chemical contaminants.3/ Many of the most troublesome chemicals are toxic, and some have been linked to cancer in test animals. For example, the suspected carcinogen trichloroethylene (TCE), has been found--if only rarely--at levels as high as 500,000 ppb (parts-per-billion) in heavily contaminated ground water. Typical concentrations in ground water are significantly less than 100 ppb, but surface water concentrations seldom exceed 1 ppb. EPA's health advisory on TCE recommends safe levels of TCE in drinking water at 2,000 ppb for an exposure duration of 1 day and at 80 ppb for a duration of one to two years, based on toxic effects. The companion guidance on cancer risks projects excess risk due to drinking water contaminated by TCE to be one in a million at a lifetime exposure level of 2.8 ppb.4/ The Agency is also proposing drinking water regulations which includes TCE as one substance to be controlled.

2. THE SOURCES OF GROUND-WATER CONTAMINATION

The diversity and number of existing and potential sources of ground-water contamination are large. There are three categories of sources of ground-water contamination: waste disposal, non-disposal use of chemicals on the surface of the land, and salt-water encroachment in response to ground-water development. As a result of differences in hydrogeological conditions and ground-water use, the threat posed by these sources varies greatly with each specific site.

States assess ground-water contamination problems on the basis of severity and/or frequency of degradation. The following is a brief listing based on anecdotal information of the problems States have identified: 5/

Major problems: industrial landfills/lagoons; municipal landfills/lagoons; underground storage tanks; and chemical oil and brine spills.

Intermediate problems: well injection; pesticides; fertilizers; and septic tanks.

Minor problems: salt water/brackish water intrusion; road salts; and feedlots.

Varies: wastewater treatment; land use; and mining background.

Some of the more troublesome contaminants from these sources include:

- gasoline (ethylene dibromide/ethylene dichloride, benzene, toluene, lead)
- organic solvents (TCE, TCA, benzene)
- heavy metals (cadmium, lead, chromium, mercury)
- inorganic chemicals (ammonia, cyanide)
- organic chemicals (PCB, PBB)
- soil fumigants (DBCP, EDB, aldicarb) and other pesticides
- pathogens and nitrates

One estimate indicates that there are now over 61,000 chemicals on the market and several hundred are added each year.6/

Improper waste disposal accounts for a substantial amount of ground-water contamination. Many types of waste disposal pose obvious risks to ground-water quality. Despite this, past decisions on locating hazardous waste disposal facilities give evidence of scant consideration of potential adverse impacts on ground water. Indiscriminate disposal of toxic and hazardous chemicals onto the land has given rise to Federal and State cleanup programs under the Superfund legislation. While the full number of such facilities remains unknown, EPA and the States have identified approximately 16,000 potential sites, including disposal sites. Some 5,600 of these sites have undergone preliminary screening, and 546 of them are now listed for priority attention under Superfund.7/

In addition to facilities receiving hazardous wastes, other facilities that may contaminate ground water are of concern. In the mid 1970's, EPA and the States' became increasingly concerned that all waste disposal landfills (not just those receiving hazardous wastes under RCRA) may be creating a substantial problem for ground water. There are an estimated 93,000 such landfills in the United States. Of these, 75,000 are classified as on-site/industrial, and we know little about them. Another 18,500 are classified as municipal.8/ Fewer than 10 States require any form of regular monitoring for ground-water quality at these facilities. Landfills are invariably located on land that is considered to have little or no value for other use, -- such as marshlands, abandoned sand and gravel pits, old strip mines or limestone sinkholes -- all of which are susceptible to ground-water contamination problems. 9/

A similar situation obtains at pits, ponds, and lagoons--usually grouped and referred to as surface impoundments--that receive both hazardous and non-hazardous wastes. EPA's recently completed Surface Impoundment Assessment (SIA) surveyed the numbers and locations of surface impoundments, and estimated their potential effects on ground-water quality.10/ The SIA defined impoundments to be any significant man-made or natural depression used to treat, store or dispose of waste (agricultural, mining, oil and gas, municipal and industrial).

The study was not field-verified and so is subject to error. Still, it presents an initial working estimate of the number, location, and water quality impact of surface impoundments. The SIA identified a total of 181,000 surface impoundments. Most of them are unlined. About 40 percent of municipal and industrial impoundments are located in areas with thin or permeable soils, over aquifers currently used for drinking or that could be used for drinking. About seven percent of all sites appear to be located so as to pose little or no threat to ground water. Because of the lack of generally available knowledge, ground-water protection was rarely, if ever, considered when these facilities were sited.

Septic systems also discharge high volumes of waste to ground water. In some parts of the country, primarily in the eastern half of the country, they are among the most frequently reported sources of contamination.11/ Approximately 20 million American households, or 29 percent, use this type of on-site waste disposal system. Assuming a 50-gallon daily discharge per capita, household septic tanks handle about 3.5 billion gallons of waste per day.12/ The primary health hazard is the introduction of pathogens and nitrates to ground water, but the presence of organic cleaning solvents is of growing concern as well.

Other practices may account for up to two-thirds of the incidents of ground-water contamination.13/ Use of pesticides and fertilizers, chemigation (where chemicals are mixed with irrigation waters), coating of roads with waste oils, use of highway de-icing compounds, leaking underground storage tanks and pipelines, accidental spills and "midnight dumping," abandoned wells, drawdowns causing encroachment of salt water, and poorly managed artificial recharge have all caused ground-water contamination. Many of these practices go on with little recognition or concern for their potential impact on ground-water quality.

Leaking storage tanks may be causing the most serious risks to human health and the environment. Such tanks are used to store liquids of every description, including gasoline, hazardous and toxic chemicals, domestic fuels, process chemicals, and dilute wastes. Storage tanks are installed either above or below ground. Incidents of contamination from above-ground tanks, though less common, usually result in significant environmental damage, since they often involve large volumes of lost product. A number of factors account for leaking tanks, including age, soil conditions, and improper installation.

Nationally, there are an estimated 1.5-2.0 million underground storage tanks now being used to store gasoline, the vast majority of which are steel. A small fraction of these are made of specially protected steel,* and another small fraction of tanks are made of fiberglass.14/ Some experts estimate that between 75,000 and 100,000 underground storage tanks are leaking right now and the number is rising.15/ However, these estimates are based on statistical estimates of the likelihood of tank leakage rather than field testing of the rate or extent of leakage. We know much less about underground storage tanks used for pure (process) chemical storage, or hazardous and nonhazardous waste storage.

About one million of the steel tanks now in the ground are more than 16 years old and unprotected (e.g., by double liners or cathodic protection). About 40 percent of all steel gasoline storage tanks underground in the U.S. belong to gasoline stations, and approximately 40 percent of these belong to major oil companies. The other 60 percent belong to small oil companies, jobbers, industries, and individual station owners. Unlike the major oil companies, which have significant tank protection and replacement programs underway, this sector has not established a comprehensive protection program. 16/

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*/ Cathodically (an electrical method for neutralizing electrical currents in steel tanks for corrosion protection).

The Maine Department of Environmental Protection (DEP) estimates that there are a minimum of 10,000 retail gasoline storage tanks in the State and that 25 percent of them may be leaking. The estimated annual loss from these leaking underground storage tanks is 11 million gallons for this one State, although it is not known how much of this seeped into ground water.19/ (It is important to note that Maine's estimate may not be representative and cannot be applied across the nation.)

3. THE EXTENT OF GROUND-WATER CONTAMINATION

Information on the current extent of contamination is far from adequate to quantify the severity of the problem. Despite numerous, well-documented incidents that continue to come to light, EPA and the Nation as a whole lack a reliable means to systematically measure the amount of damage already done and likely to occur. A great deal of information has been assembled over the years, but it has focused primarily on traditional parameters affecting potential use, like salinity. Only recently have advances in analytical chemistry enabled scientists to measure specific chemicals at low levels and begin to assemble information on chemicals of most concern as risks to public health.

Due to the nature of the resource, it is very unlikely that a comprehensive picture of ground-water contamination will ever be available from ambient monitoring data. The vastness of the ground-water resource makes the cost of significant ambient monitoring prohibitive. While anecdotal data does not tell much about the extent of the real problem, it does indicate that a problem may exist and highlights the need for further investigation.

For now, we must rely primarily on such data as that collected by other Federal and State agencies and at RCRA and Superfund sites to expand knowledge of the problem. For example, EPA expects that required monitoring of the approximately 1,500 existing hazardous waste disposal facilities will bring to light more contamination incidents. A recent EPA study identified and characterized 929 documented cases of contamination from abandoned hazardous waste facilities. Although the study is not based on a representative sample, about one-third of the 929 cases involve documented contamination of ground water. In an additional one-third, ground-water contamination is strongly suspected. 18/

In addition, we must make use of data on well closings, such as that reported in recent Congressional and EPA studies. These reports together show that nearly 8,000 private, public, and industrial wells have been reported closed or affected by toxic and other forms of contaminated ground water. It is very probable that many more wells were closed but the closings were never documented. 19/

The Ground-Water Supply Survey recently conducted by EPA illustrates the potential for ground-water contamination by organic chemicals. This survey covers the Nation's 48,000 public water systems drawn from ground water. The survey found that man-made chemicals are being detected in about one-third of the large public water systems (serving over 10,000 people) but are being detected in only about one-fifth of all ground-water systems. This indicates that some contamination exists and that the water supply, as well as potential sources of contamination, should be carefully examined.20/

Only about three percent of these systems detected levels of contamination at the levels at which EPA is considering establishing drinking water standards (5-50 ppb). Although the vast majority of these systems are finding levels of contamination of little significance to public health, it is nevertheless disturbing that they are being found at all. Since these chemicals are not naturally occurring, they must come from human activities. Unless the sources can be found and managed, serious problems may lie ahead.

There are few data on ground-water contamination in the 160,000 non-community systems (those serving a transient population). There are also virtually no data related to man-made chemicals in the 12-14 million individual wells, even though many are old, shallow, and most vulnerable to contamination.

In addition to the man-made organics discussed above, other Federal and State studies have found other types of more conventional contaminants -- such as chlorides, sulphates, nitrates, and metals -- in ground-water supplies at levels that may cause a public health problem.

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Conclusions

Based on review of the preceding information, the Agency drew a number of conclusions in support of the ground-water policy development effort. They are as follows:

1) Based primarily on anecdotal data, ground-water contamination may be a widespread problem that deserves increased attention. Virtually every State in the Nation has detected ground-water contamination affecting use, and the monitoring efforts currently underway are expected to identify many more problems. Whenever these situations have surfaced, public concern has been intense, especially where drinking water supplies have been affected. Sufficient information is available to raise concerns that a widespread problem may exist.

2) Ground water is vulnerable to contamination, expensive to monitor, difficult to clean up, and not usable once seriously contaminated. General misunderstanding of the nature of groundwater has subjected the resource to pollution by many past actions involving the use and disposal of chemicals on and in the land. Cleaning up contaminated ground water is difficult, expensive, and often unsuccessful. These facts clearly argue for future programs to focus on better protection of the resource while efforts to detect and deal with serious contamination resulting from past actions continue.

3) Surface impoundments, landfills, and storage tanks must be better designed and constructed. Reports of ground-water contamination from surface impoundments, landfills, and storage tanks have been growing over the past few years. The attention of EPA and the Congress has been drawn to these sources as areas where additional national controls may be needed. Although there are other important, uncontrolled sources, these categories appear most in need of effective regulation.

4) More factual information is needed to determine the actual extent and severity of the ground-water contamination problem in the country. The nature and extent of ground-water contamination should receive more attention from the Federal government, particularly EPA, and the DOI. In particular, agencies should make usable data from existing sources of information more accessible to managers responsible for ground-water protection at all levels of government.

The importance of the ground-water resource will continue to increase. The present ground-water contamination problem is expected to appear more severe as additional information is collected, because the probability that many sources are contributing to the problem is high. Further studies of the nature and extent of the problems should indicate the significance of contamination sources to the quality of ground water and provide information concerning the fate of the contaminants and their potential impact on human health and the environment.

WHO IS RESPONSIBLE FOR PROTECTING GROUND WATER?

The Ground-Water Protection Strategy was developed in full recognition of EPA's recently released policy statements on delegation and oversight. The clear intent of those policies is to make use of Federal, State, and local governments in a partnership to protect public health and the environment. State and local governments are expected to assume primary responsibility for the implementation of environmental programs because they are best placed to address specific problems as they arise on a day-to-day basis. The EPA role is to provide national environmental leadership, develop general program frameworks, establish standards required by Federal legislation, conduct research and national information collection, provide technical support to States, and provide assistance to States in strengthening their programs. The Federal, State, and local roles as expressed in this Strategy are completely consistent with EPA's delegation and oversight policies.

The EPA role identified above will involve cooperation from other Federal agencies, especially regarding research information collection and technical support to the States. The EPA will provide program leadership and technical assistance to the States in matters involving the protection of ground-water quality, and will rely on the Department of the Interior and the U.S. Geological Survey (USGS), for assistance in defining the hydraulics and geochemistry of ground-water flow. In addition, USGS will provide technical assistance (largely through its "Federal-State Cooperative Program"), will conduct basic and applied research in ground-water physics and chemistry, and will work with EPA to help develop and support effective monitoring strategies.

EPA's Ground-Water Task Force examined Federal legislation and State program authorities to determine whether sufficient statutory and regulatory flexibility exists to protect ground water. The range of authorities at both levels is quite broad, but we need to make better, more closely coordinated use of them. The Task Force findings and conclusions follow.

Findings

Three levels of government--State, local, and Federal--have substantial responsibility for ground-water protection. Until the mid-1970's, it was principally the States and localities that were concerned with protecting the quality of ground water. Many did not recognize ground-water contamination as a significant problem. Federal environmental programs of the early and mid-1970's focused on other media or on chemicals of concern: the Clean Air Act (CAA) for air; the Clean Water Act (CWA) for surface water; the Safe Drinking Water Act (SDWA) for drinking water; and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) for pesticides.

In the late 1970's, significant threats to ground water by man-made contaminants became apparent, and ground water emerged as an area of major public concern. Regulatory and technical assistance efforts of EPA's drinking water program began to turn in that direction, as States signaled their need for information upon which to base their responses to contaminated ground water found in public and private drinking water wells. At the same time, new Federal statutes were passed to address additional environmental threats: TSCA for control of commercial toxics; RCRA for hazardous waste management; and CERCLA for abandoned waste sites.

Several of the older statutes--CWA, SDWA, and FIFRA--have authorities that can be applied to ground-water protection. The newer statutes have provisions that are, in some cases, even better suited to the task. So, in addition to the traditional activity of States and localities, we now have a broad arsenal of Federal statutory authorities to apply in the prevention and control of ground-water contamination. Attachment I contains a brief summary of the roles that the three levels of government--local, State, Federal--have assumed for ground-water protection.

States, with local governments, have the principal role in ground-water protection and management. Based on historical State authorities, as well as Federal program authority delegated by EPA, States are best suited to undertake direct implementation and enforcement of ground-water protection programs. A variety of institutions at the State and local levels address the problem of ground water. Approximately 40*/ States have general environmental statutes which include authority to protect ground water; 15 States have laws that apply specifically to ground water. Forty-seven States have more than one major agency dealing with ground-water issues, some have as many as eight.21/

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*/ References to States include territories, for a total of 57 jurisdictions.

States use different mechanisms to protect ground-water quality. For example, about 32 State governments use general water quality standards to supplement Federal standards for ensuring safe drinking water supplies. Over 40 State governments require some type of discharge permit, though most discharge permits are written to protect surface waters. Eleven States now have some form of ground-water classification in place. Several States have the authority to impose some type of State land-use controls, but only a few actively use them to protect ground water.

To deal with contamination incidents, at least 21 States have established cleanup funds. Use of these funds varies, from helping to cleanup sites included in the Superfund program to dealing with sites excluded from Federal programs.

Nearly 40 States maintain monitoring networks for determining the general quality and quantity of ground water within the State, while about the same number of States actively monitor the ground water surrounding the major contamination sites. Over 40 States have programs to notify and educate the public regarding ground-water issues.

The management of ground water takes place in many ways. Thirty-nine State governments organize their ground-water protection work under the auspices of a lead agency. Fifteen other State governments recognize a lead agency only informally. Most States have written procedures and agreements for coordinating ground-water activities, although 12 rely on informal methods to coordinate.

Finally, most States either conduct work in support of nationally managed programs or implement programs delegated by EPA, including RCRA, UIC, portions of CERCLA, and the CWA Construction Grants program. By October 1984, EPA expects that there will be a UIC program in every State and jurisdiction. At that time, 33 States will have primary enforcement responsibility for all classes of wells; three states will have authority for oil and gas related wells only; one state will have authority for all wells except oil and gas. EPA will be implementing the remaining programs. In terms of the regulated universe, 73 percent of disposal wells, 92 percent of oil and gas wells, and 97 percent of mining-related wells will be regulated by States. (Fourteen States have full primary enforcement authority delegated under the UIC program, and 11 others have partial enforcement authority. A Federally-administered UIC program has been proposed in 23 States.)

Under the RCRA program, 45 States have at least interim authorization to exert certain controls over hazardous wastes facilities. To date, 13 States have interim authorization to issue permits to land-based facilities. By statute, all States with interim authorization under RCRA must obtain full authorization by January 1985. Under CERCLA, EPA has signed cooperative agreements for 52 sites where the State is the lead agency for remedial actions; EPA retains control over the selection of the cleanup alternative at these sites. Under FIFRA, States have primacy in pesticide use enforcement. Pesticide use restrictions imposed by EPA can be enforced by individual States.

Local governments can also play a major role in ground-water protection. They derive their authorities from State environmental statutes or from related, powerful authorities, such as those to protect public health and to control land use. Through local zoning, lot sizes have been regulated into a few localities to prevent intensive residential or commercial development over recharge areas. In other cases, localities have enacted bans on the siting of waste disposal facilities where ground-water contamination could occur. Some communities also set restrictions on the density of septic systems. Some areas, like Long Island and Cape Cod, have enacted strict, local control programs to protect ground water.

While State and local governments have moved forward to address contamination of their ground water, they have been hampered by the lack of a ready answers and the absence of staff trained in a technological and scientific discipline still in its developmental stage. New Federal efforts to help States cope with these problems have proved useful, but they have also contributed at times to competition and overlap. State institutions have been sorely taxed to take on new responsibilities, deal with contamination sources not covered by Federal statutes, and fashion a comprehensive effort to protect both the quality and quantity of their ground water.

EPA's statutes, while designed for more general purposes, provide substantial protection for ground water. EPA must apply these authorities flexibly and imaginatively in programs that take into account widespread threats to the resource. Several such programs are just beginning to come into effect, while others have been in place for some time.

CERCLA establishes a trust fund (Superfund) to finance government responses to releases, or threats of release, of hazardous substances that may harm health or the environment. Superfund can address these problems not only in emergency situations, but also at sites where longer term remedies are required. The statute directs that a priority list of at least 400 sites be identified as candidates for remedial action.

A major factor in evaluating sites for response action is the threat of ground-water contamination. Of the 539 sites now listed for priority attention, 410 appear to have caused ground-water contamination.

Under RCRA, EPA has implemented regulations to provide "cradle to grave" management of hazardous waste. The program includes standards applicable to generators and transporters of hazardous waste and performance standards for permitting hazardous waste treatment, storage, and disposal facilities. The standards establish the principal ground-water protection policies of the RCRA hazardous waste program. EPA has also established criteria for non-hazardous solid waste disposal under Subtitle D of RCRA. States must adopt and enforce these criteria, if they are to have an EPA-approved State solid waste management plan. EPA has completed all major statutory requirements under Subtitle D of RCRA excepting the duty to review and approve State plans within six months of submission. Some States have not submitted plans but intend to do so. Citizens may seek enforcement of these criteria directly in Federal district courts.

In addition, EPA is progressing with implementation of the UIC program under the SDWA. It ensures that injection well practices do not threaten present and future sources of drinking water. The UIC program will regulate approximately 160,000 wells by permit or rule.

The sole-source aquifer program under the SDWA permits citizens to petition EPA for designation of an area as a sole-source aquifer if it is the principal water supply. If so designated, EPA reviews all Federally-assisted projects which may affect the quality of ground water in the sole-source aquifer.

EPA is also preparing regulations to establish standards under the SDWA for certain volatile organic chemicals and pesticides, which are the most commonly found contaminants in ground water. When enacted, these regulations will require monitoring by public water systems to protect users at the point of human consumption. Monitoring requirements for private wells are a State responsibility. The new monitoring requirements are particularly important, since half the Nation's population drinks water from underground sources.

The CWA provides a management structure for State water quality programs, including ground water. At one time, a number of States used funds provided under Section 208 of the CWA to conduct ground-water management programs. EPA's CWA funding policies require that such activities must result in an official update to the State's overall Water Quality Management (WQM) plan, and require consistency between the WQM plan and all related treatment works construction grant and National Pollutant Discharge Elimination System (NPDES) permit decisions. Eleven States now use funds under Section 205(j) to support selected ground-water protection efforts. Under other provisions of the CWA, construction grant projects employing land application techniques to reuse and recycle nutrients must be designed to ensure protection of ground water for continuation of present use or for future use projected on the basis of present quality. The CWA also provides authority under Section 404 to protect wetlands, which are commonly fed by ground water.

EPA also has an active program under FIFRA, which provides authority to control the use of pesticides that may adversely affect ground water. EPA has in place registration and testing guidelines for evaluating the potential for pesticide chemicals to leach into ground water. EPA can use a variety of methods to limit potential damage, such as restricting the use of certain pesticides with a high likelihood of leaching into ground water.

TSCA provides EPA broad authority to regulate new and existing chemicals and chemical mixtures by exercising control during their manufacture, processing, and use, as well as at their eventual point of contact with people or the environment. For example, if a chemical has the potential to contaminate ground water, EPA has authority to limit certain uses, require warning labels, impose pollution control measures, alter disposal plans (with certain limitations), and require additional notifications after manufacture has begun.

EPA also has a significant research effort devoted to ground-water protection, concentrating on major management and scientific problems associated with the resource (see discussion in Chapter IV). Among the major topics of this research are: developing methods to protect and monitor ground water, tracking and measuring the transport and transformation of pollutants to the point of human exposure, determining health effects associated with various pollutant concentrations in ground water used as drinking water, and assessing the cost-effectiveness of aquifer reclamation.

Two major sources of ground-water contamination remain largely uncontrolled by current EPA programs. A number of sources of contamination described in Chapter II are regulated by EPA (hazardous waste facilities, underground injection wells) but many more are not. States retain authority to regulate in areas not regulated by EPA. In addition, EPA believes that two of these unregulated sources appear to be of sufficient concern to warrant national attention. They are storage tanks and land disposal facilities (surface impoundments and landfills) for non-hazardous wastes and chemicals and other products, by-products, and intermediates. Land disposal of non-hazardous wastes are addressed under Subtitle D of RCRA. Only States and citizens may seek enforcement of these standards.

As for storage tanks, it is becoming increasingly obvious that we must learn a great deal more about the problem before any regulatory action is proposed. Furthermore, a number of States have already made progress on this issue by undertaking an inventory of these potential sources of pollution. Some States, like Maryland and California, are establishing design standards and criteria for installing, testing, and maintaining underground storage tanks used for hazardous wastes. In addition, several major oil companies, long aware of their potential liability, have begun an aggressive program to replace old metal tanks and to institute periodic inspections, better inventory controls, and cathodic protection.

With regard to surface impoundments, State programs have changed substantially since EPA conducted the initial Surface Impoundment Assessment in the late 1970's. These changes are the result of increased awareness and concern by the States and new Federal programs such as Subtitle D of RCRA.

The majority of States have some type of regulatory program that involves a system of permitting waste impoundments under either State or Federal authority. Some States have added to their NPDES programs provisions which address ground-water contamination. The more traditional programs, however, focus on the treatment phase of an entire facility or on the direct discharge of wastes to surface water rather than on ground-water contamination. Even State programs based on specific legislation usually focus on point-source discharges to surface water rather than on seepage and non-point source pollution of underground water.

A few State programs (New Mexico, New Jersey, Pennsylvania, California, Wyoming) directly control the discharge of wastes to ground water. However, the level of effort is quite uneven among the States in providing effective and necessary planning, review, inspection, monitoring, and enforcement to ensure compliance.

EPA regulations are inconsistent with regard to a number of issues relating to ground water: defining the resource to be protected, allowing for differential protection, setting the duration of control, prescribing the regulatory mechanism to be used, providing for some kind of waiver or variance, and stipulating the approach to monitoring and remedial action. Table A (page 31) illustrates the range of these inconsistencies. Attachment II presents a more detailed analysis of EPA regulations.

It is important to note that some apparent inconsistencies may, in fact, be justified. Despite this, a number of discrepancies may have no technical basis, and merely reflect different policy or management decisions by different people at different times.

The practical implications of these differences to the management of EPA programs can be illustrated by reference to some of the short- and long-term regulatory and program issues EPA now faces:

- Litigation issues. Two RCRA law suits raise significant issues of ground-water protection policy. In particular, both suits raise issues about what ground water should be protected. In one litigation, petitioners have raised issues concerning the removal of certain ground waters from the protections afforded by Subtitle C based on the quantity of the aquifer and its current and potential future uses. The Agency has deferred settlement of these issues pending the development of its ground-water strategy. In the other litigation, petitioners challenged the ground-water protection criteria of RCRA Subtitle D applicable to facilities handling non-hazardous solid wastes. In settlement negotiations, the petitioners have proposed a variety of approaches to protecting ground water, most of which were aimed at providing flexibility to account for differing existing and future ground water uses. The court has deferred briefing this issue at the request of the parties until the Agency's ground-water Strategy is finalized.

- Alternate concentration limits (ACLs) in RCRA. EPA has started evaluating land disposal permits. This work will require decisions on applications for alternate concentration limits. The criteria that EPA has established to date relies on a showing by the applicant that an alternate concentration will not pose a substantial present or potential hazard to human health or the environment. One issue that has emerged is how to evaluate ACLs in ground water that is already contaminated. In establishing a policy in this area, it is important that the definition of "already contaminated" under RCRA, and the RCRA policy on ACLs in those ground waters, be consistent with definitions and policies of other EPA programs. The class definition and protection guidelines in this Strategy will ensure that consistency.

- Aquifer exemption in UIC. Under UIC, EPA may grant an exemption allowing injection into an aquifer that meets the definition of an underground source of drinking water (i.e., less than 10 000 mg/l TDS) if the aquifer contains toxic contaminants at levels that render its use impractical. The decision on what levels and types of contaminants render the aquifer unsuitable for use as drinking water is one that has implications for other Agency programs such as RCRA and Superfund.

- FIFRA/SDWA interface. The Office of Pesticide Programs and the Office of Drinking Water have developed a procedure for establishing advisory levels for pesticides in drinking water. The purpose of these levels is to render advice to State health officials for use in dealing with episodes of contamination. These levels, unlike tolerance levels for pesticides residues in food, do not reflect a level to which it is acceptable to contaminate drinking water, but rather a level for which remedial action is recommended. These advisories have potential application to other Agency programs such as RCRA and Superfund. For example, it is important that these advisories, guidance on ACLs (under RCRA), and cleanup criteria under Superfund be well coordinated.

- "How Clean is Clean?" Superfund managers must decide and EPA's enforcement program under emergency authorities (principally those under RCRA and CERCLA) must compel private actions that answer the question: "how clean is clean" in ground-water cleanups. Currently, the Agency is attempting to develop more specific decision criteria for determining levels to which contaminated ground water should be restored. This issue has broad implications within the Agency and is related to other Agency activities such as the development of health advisories. The Ground-Water Strategy provides a framework for developing these criteria based on the ground-water protection guidelines defined in the Strategy.

- Protection for especially valuable aquifers. Some ground waters are clearly more valuable than others and more susceptible to contamination. Some are critical sources of drinking water or provide base flow for particularly sensitive ecosystems. States and EPA could design an added level of protection for these ground waters by prohibiting certain practices over them. The RCRA program has begun to develop rules for locating hazardous waste facilities and will be considering limiting hazardous waste management activities over ground water that is highly vulnerable to contamination. Decisions made in this program will have policy implications for other programs. It is important that the level of protection provided by EPA's various regulations for highly vulnerable or valuable ground water be consistent and that various Agency programs define such ground water in a consistent way.

Conclusions

1) Building institutions, especially at the State level, is critical to the comprehensive management and protection of ground water. Many States have made major strides in increasing their capabilities to protect ground water, despite the difficulties implicit in this complex problem. While many States have expended substantial efforts to build and coordinate their State programs and have comprehensive programs that are in development or under operation, these efforts are still insufficient to ensure protection for a resource that demands a comprehensive approach.

2) EPA must achieve greater consistency among its programs if they are to have maximum effect in protecting ground water. EPA rules which protect ground water are sometimes inconsistent with one another, leading to conflicts, duplication, and different degrees of protection from program to program. This heightens the difficulty of decision-making by regulators as well as by regulated industries.

Sufficient flexibility exists in the rules and policies adopted under each EPA program such that it has been possible to craft an acceptable, case-by-case solution to problems created by apparent program inconsistencies. However, over the next few years the effects of program inconsistency are likely to become increasingly disruptive as RCRA, CERCLA, and UIC move to full implementation unless steps are taken to provide needed policy direction.

3) EPA has had no lead point of accountability and coordination for ground-water efforts at either the Headquarters or Regional levels. Ground-water program efforts are located in four offices in EPA headquarters: Office of Solid Waste and Emergency Response (RCRA and CERCLA); Office of Water (SDWA and CWA); Office of Pesticides and Toxic Substances (TSCA and FIFRA); and Office of Air and Radiation (Uranium Mining and Mill Tailings, Reclamation and Control Act (UMTRCA) and Atomic Energy Act (AEA)). The Regions have a similar configuration. Each performs functions related to ground-water protection and has responsibilities that overlap to some extent with those of others. Prior to formation of EPA's new Office of Ground-Water Protection, no single official below the Administrator has had the authority to establish policy or to coordinate these programs.

The Agency has either relied on general-purpose policy coordination mechanisms--such as Steering Committees--to resolve conflicts among programs, or has established ad hoc committees--such as Task Forces--to resolve specific issues. These methods have proven helpful, but they do not give EPA the capacity to provide unified direction to its ground-water protection effort over time.

Table A - Summary Table - Existing Federal Ground-Water Protection Programs

	Scope - what Resource is Protected?	Differential Protection of Groundwater?	Duration of Control?	Regulatory Mechanism?	Waiver/variance Provision?	Monitoring and Remedial Action Approach
SDWA-UIC Parts 144-146	Aquifers which could supply PWS with <10,000 mg/lTDS	Yes-Class V wells can degrade up to MCLs vs. no degradation for class I, II, III	During well operation, but presumably forever	Classes I to III-Design Standards Class V-non endangerment of USDWs	Yes-exempted aquifers can be designated	Specified in Permits
RCRA-264	Uppermost aquifers	No increase in hazardous waste constituents or no violation of MCLs	30 years post closure for disposal facilities	Design and performance standards	Yes-risk based alternate concentration limits on case-by-case basis	Monitoring and remedial action required
RCRA-257	Current USDWS and GW with <10,000 TDS	Maintain drinking water standards	Unspecified - regulatory scheme implies forever	Design and performance standards	NONE	NONE
UMTRCA	Uppermost aquifers	Yes-no increase in Mo or U. Radium 226/228 up to 5pCi, Gross Alpha up to 15pCi	Design objective of 200-1000 years	Design standards - liners required	NONE	Case-by-case decisions
TSCA-PCB Part 761	Groundwater (undefined)	No-no release of PCBs to any groundwater	20-years post closure	Design and location standards	NONE	Monitoring Required
CWA-Constr. Grants Part 35	Uppermost aquifers with 3 classes based on current and potential uses	Yes-protection to levels set by three classes	Unspecified	Best practicable waste treatment technology	NONE	Case-by-case monitoring to demonstrate compliance
FIFRA - Pesticide Policy	Groundwater	No-max. advisable level based on no effect on 10kg child drinking 1 liter/day	As long as the pesticide is registered	Controls on or prohibition of use of specific pesticides	NONE	Monitoring can be required of registrants if GW contamination is concern
High level Rad. Wastes	Groundwater (undefined)	Yes-Some aquifers become part of disposal site	10,000 years	Design and performance standards	NONE	NONE
CERCLA-NCP	Which could supply PWS or use by more than one person using scoring system	Yes-Decisions on a case-by-case basis	Unspecified	Case-by-case decisions	Case-by-case decisions	Case-by-case decisions

NOTE: This is an abbreviated summary of Attachment II.
It is not intended to describe programs fully or to provide detail on regulatory requirements.

EPA'S STRATEGY TO PROTECT GROUND WATER

The principal challenge to EPA in developing a ground-water Strategy is to harmonize the implementation of its many ground-water programs and to enhance its partnership with the States to increase protection of this critical resource.

STRATEGIC CHOICES

In designing its Strategy, EPA faced a number of difficult choices. One strategic choice was to decide what role EPA should play in ground-water protection, recognizing that the States have fundamental responsibility for protection and management of the resource itself. EPA's statutes concentrate on specific contaminants and on specific sources of contamination, yet due to its vulnerability, ground water frequently demands more comprehensive protection. EPA sees the need to strengthen the ability of States to carry out this critical function. Only through strong, carefully designed State programs can the objective of comprehensive management be achieved.

A second strategic choice involves by what means and to what extent ground-water resources should be protected. EPA programs have begun to show inconsistency in specific decisions such as site cleanup, enforcement conditions, and application of waivers. The question is whether all ground water should be protected to the same level, or whether decisions relative to the appropriate type and level of protection should reflect the value of the resource. While an unspoiled environment is an attractive goal, the potential cost of protecting, monitoring, and restoring a resource so vast as ground water is enormous. This fact necessarily affects the decisions of managers at all levels, especially regarding the use of scarce public funds.

The Agency also considered whether it is proper from a public policy perspective to clean up all or portions of a resource that almost certainly will never be used. The Agency also asked whether it is doing enough to protect geologically vulnerable ground water that is essential to human uses, or that feeds highly sensitive or unique ecological systems. In certain of these cases, when the cost of *in situ* cleanup has been prohibitive, States have chosen to mitigate the damage by modifying the flow pattern of plumes, changing use patterns for wells, or treating the water at the point of use. EPA concluded that, while flexibility is essential, we should strive for greater consistency in ground-water decisions. This implies the need for guidelines to shape EPA program actions and in turn to provide leadership to the States.

In carrying out the Strategy, EPA will, to the extent possible, use the existing experience of other Federal agencies, such as the USGS. Cooperation is essential in order to minimize duplication of effort in the Federal sector and to ensure the development of a technically sound effort.

A final strategic choice is how to enhance consistency and coordination among EPA programs over time. Unlike the other media in which environmental pollutants are found--air and surface water--ground water previously has had no organization devoted to its protection. It is, rather, an integral part of many programs. A key strategic choice is how to emphasize and coordinate these programs without disrupting ongoing activities.

As EPA reviewed these strategic choices, it became clear that not everything can be done at once. An attempt to resolve every issue among EPA's diverse programs with the stroke of a pen will inevitably disrupt other important ongoing efforts. We cannot change in a moment institutional patterns that have developed gradually in response to other problems. We can accelerate the development of new knowledge only as fast as the scientific community can respond. Still, we can make steady progress, and we can accelerate the pace of work now underway, particularly at the State level.

EPA'S GROUND-WATER PROTECTION STRATEGY

EPA's Ground-Water Protection Strategy seeks to build up institutional capability in the States and within EPA to cope with ground-water problems on a comprehensive basis. The Strategy will provide greater consistency and coherence among EPA programs aimed at protecting ground water and will initiate new steps to deal with major forms of ground-water contamination not now fully controlled. The core elements of the strategy are to:

-- Strengthen State ground-water programs;

-- Cope with currently unaddressed ground-water problems;

-- Create a policy framework for guiding EPA programs; and

-- Strengthen internal ground-water organization.

1. STRENGTHEN STATE GROUND-WATER PROGRAMS

EPA will provide increased support to States for program development and institution building. EPA believes that the most effective and broadly acceptable way to increase national institutional capability to protect ground water is to strengthen State programs. Some States have already achieved excellent results, while others are progressing more slowly. Enhancing and accelerating these efforts should provide meaningful and lasting results.

EPA will encourage States to make use of existing grant programs to develop ground-water protection programs and strategies. EPA will work with States to develop institutional capability to protect ground water. States will be encouraged to prepare or enhance their ground-water program development plans, including an analysis of ground-water problems and needed ground-water protection activities. States should also identify technical assistance needed from EPA.

The work EPA will support is comparable to that undertaken over the past several years by States that have already developed ground-water protection programs, and will include program development activities such as:

1) Development of an overall State action plan or strategy to set ground-water protection goals and to coordinate ground-water programs in various institutions;

2) Identification of legal and institutional barriers to comprehensive ground-water protection programs;

3) Development of general ground-water programs (e.g., a permit system) and design of a source- or contaminant-specific ground-water protection program; and

4) Creation of data management systems to increase the accessibility and quality of needed information.

Since some States have already completed some or all of these tasks, the Agency will support activities to assess the ground-water resource (e.g., mapping, selected monitoring) as long as they are presented in a broad context indicating how they fit into an overall State ground-water strategy. EPA will not support routine operational or implementation activities as a part of ground-water program development activities.

Seven million dollars are available in Fiscal Year (FY) 85 for this purpose from CWA Section 106 water quality management grants. Funds from a range of existing grant programs are also eligible to support ground-water program development activities, including grants under sections 205(j) and 205(g) of CWA, the UIC program grant under section 1443(b) of the SDWA, and the program grant under section 3011 of RCRA.

EPA Regional Administrators will work with Governors in ground-water program and strategy development. Regional Administrators will work with Governors to identify the most appropriate mix of eligible grants and level of funding to support ground-water program development. EPA will make every effort to avoid serious impacts on a particular, existing program in a given State. RCRA funds will not be available until a State has met its RCRA program implementation commitments.

EPA will provide State agencies with technical assistance in solving specific ground-water problems and will enlist the aid of other Federal agencies whose particular expertise or programs provide valuable capabilities EPA staff in Headquarters, Regions, and laboratories, as well as other Federal agencies, will provide assistance to States in several areas: 1) technical and scientific issues; 2) State program design and implementation; 3) identification of research needs, 4) data management; and 5) training.

EPA will continue to support a strong research program in ground water and will work closely with other Federal agencies, especially the DOI. EPA conducts a research program to provide a broad range of data and information for use by decision-makers concerned with ground-water protection. The ground water research program is directed toward improving monitoring technology, prediction and assessment tools, and aquifer cleanup methods. Other research programs also contribute to the scientific bases upon which decisions about ground-water protection are made. For instance, a significant portion of the research on the health effects and removal of drinking water contaminants is directed toward chemicals found in ground water. Research to develop and evaluate technology for control of sources (such as surface impoundments) and improvements in methodology for analyzing water samples for trace constituents also contribute to our scientific capability. Quality assurance is always an important facet of any investigation, including those involving ground water, and remains a high priority in our research program.

2. COPE WITH CURRENTLY INADEQUATELY ADDRESSED GROUND-WATER PROBLEMS

EPA will survey inadequately addressed threats to ground water. In the Agency's review of ground-water contamination it became evident that contamination from many sources not regulated under RCRA Subtitle C or the UIC program can render ground water as unfit for use as waters contaminated with hazardous wastes. Often, too, such damage is more difficult and expensive to clean up.

Recognized sources of contamination include surface impoundments, landfills, underground storage tanks, pesticide and fertilizer uses, septic tanks, mining, unregulated drilling, natural gas pipelines, and sinkholes. Due to a lack of information, the extent and seriousness of the problems associated with each of these sources is not well understood.

EPA has found preliminary evidence that landfills, surface impoundments, and leaking storage tanks could constitute widespread problems and is initiating actions to further evaluate the threats from these sources and develop controls as may be appropriate. These actions are discussed below. For currently unaddressed sources, EPA will include in its ground-water monitoring strategy steps to help define the nature, extent, and severity of contamination from these sources.

EPA will study the effects of contamination from underground storage tanks. To protect ground water from the threats posed by leaking storage tanks, the Deputy Administrator has directed the Office of Toxic Substances (OTS) to design a study to identify the nature, extent, and severity of ground-water contamination resulting from leaking product tanks, including the human health and environmental effects that leaking underground tanks pose. This study will include motor fuel tanks. It will gather data about tank types, ownership, and the type of facility using the tanks (e.g., gasoline station, industrial, or commercial facility). OTS will test a sample of these tanks to determine the proportion now leaking. The Office will also assess testing and protection methodologies to evaluate their usefulness in a regulatory program. In future years the Office may study other underground tanks and pipelines.

In addition to identifying and characterizing the universe of storage tanks, EPA will review options for a regulatory program to control leaking storage tanks. The Agency will review the need for and nature of regulatory options for the manufacture and installation of tanks, periodic testing, improved records of product inventory, and cleanup requirements. In the meantime, EPA will issue a Chemical Advisory to alert all owners and operators of underground storage tanks to the nationwide problem of ground-water contamination caused, in part, by gasoline. The Advisory will explain that tank owners and operators may be contributing to this problem, and that EPA has begun investigating the problem and is assessing the need for future regulation of underground gasoline storage tanks. EPA will also work with the States and with trade associations, such as the American Petroleum Institute (API) and the Society of Independent Gasoline Marketers of America (SIGMA), to develop voluntary steps to reduce contamination.

The Agency is also planning direct regulation of underground storage of hazardous waste under RCRA. Regulation of hazardous waste storage is required in the RCRA statute. Although regulations are already in place for above-ground tanks and some underground tanks, standards are needed for all underground tanks. Based on data developed over the past two years, EPA will complete its regulation of underground tanks containing hazardous waste, and may amend the regulations that are already in place.

EPA will study the potential environmental problems that could arise from land disposal facilities (surface impoundments and landfills). RCRA Subtitle C rules already apply to surface impoundments and landfills accepting designated hazardous wastes. Other facilities handling non-hazardous wastes and hazardous wastes produced by small generators are covered by RCRA Subtitle D criteria (enforceable under citizen suits), but they are not regulated under the Federally enforceable provisions of RCRA. These facilities may be significant sources of ground-water contamination. EPA will undertake a study of surface impoundments and landfills, in cooperation with the States, to determine if more extensive Federal and/or State requirements are necessary and appropriate.

The study will address several questions. It will: (1) identify, describe and categorize the various types of impoundments and landfills; (2) survey the regulatory methods either now used by States or considered feasible for controlling contamination from these facilities; and (3) determine what additional Federal controls may be needed. Field monitoring of selected impoundments and landfills may be undertaken to better define the impacts on ground water of such facilities. The study will categorize surface impoundments and landfills for two reasons: first, to distinguish between those that threaten ground water and those that do not; and second, to analyze regulatory approaches appropriate to each group, thereby minimizing the regulatory burden.

EPA will increase efforts to protect ground water from pesticide and nitrate contamination. Preliminary monitoring information indicates that use of certain pesticides may be an important source of ground-water contamination. The Agency is taking several steps to assess the leaching potential and health impacts of individual pesticides and to develop and implement a program designed to mitigate the threat they pose to ground water. EPA will:

- Require pesticide manufacturers to provide data on leaching potential as part of the registration process. (This data is already required for registration of new pesticides. A data call-in program has been initiated to accelerate the retrospective review of the ground-water contamination potential from use of existing pesticides.)
- Use modeling techniques and field monitoring to evaluate the extent and likelihood of ground-water contamination from use of the pesticides.
- Continue to evaluate the potential health effects of pesticides and issue health advisories regarding drinking water contamination.
- For pesticides found to pose a threat to ground water, use labeling restrictions or other means to restrict their use in certain geographic areas based on soil type, hydrogeology, and ground-water use.
- Encourage implementation of the restrictions through incorporation of ground-water provisions in FIFRA State enforcement grant agreements and by providing technical assistance to State officials, agricultural extension personnel, and others who aid in informing pesticide users.
- Provide guidance, including health advisories and technical assistance to State officials, agricultural extensive personnel, and others to aid in informing users.

EPA will prepare a monitoring strategy involving guidelines for network design. In reviewing the question of other contaminants, EPA considered several approaches to monitoring to determine their impact on ground-water quality. These approaches are: (1) ambient monitoring; (2) monitoring at the point of contamination, (3) monitoring at point of use; and (4) a combination of these.

- "Ambient" ground-water monitoring: EPA rejected this approach because plumes are relatively small, too slow moving, and easy to miss. Further, such a costly, broad-brush approach would involve monitoring ground water with no known use or potential for human exposure. However, ambient monitoring does help define background information on quality, status of the resource, and the ground-water flow system.

- Point of contamination: Such monitoring has not been done in a systematic way although considerable data exist from testing done where contamination was strongly suspected. The RCRA monitoring program provides the first systematic data on certain contamination sources--hazardous waste land disposal facilities. The cost of a special network just to monitor the more significant categories of contamination sources would be extremely high and a questionable investment considering the potential value of the information to be obtained.

  With enforced RCRA monitoring requirements supplemented by additional wells at selected sites, important information on contamination--both existing and potential--should be available. However, this type of monitoring is restrictive as to the information it provides on the hydrology and movement of the contaminants.

- Point of use: A third approach is to sample water from drinking water wells now in use. Several such surveys have been conducted which provide a general picture of the quality of ground water used for this particularly vital purpose. EPA is now developing additional drinking water standards which will extend monitoring by public water supplies and provide more information on contaminants, like volatile organic chemicals, that are associated with ground-water contamination. A similar survey focusing on pesticides is now being planned. In addition, EPA will provide health advisories for unregulated contaminants for States to use in conjunction with their monitoring efforts. Although the importance of this type of monitoring is self evident, detection at a supply well is "after the fact" of contamination. Moreover, this type of monitoring alone does not answer all questions relative to source of contamination, status of resource, or direction and movement of ground water.

- Combination of approaches: Such monitoring would be costly if EPA were to develop a network "from scratch". However, the Agency recognizes that considerable effort has been expended by other Federal agencies (particularly USGS), State and local agencies, and even private organizations to monitor ground water. The coordination role of EPA may be put to best use by marshalling these "forces" and encouraging the use of existing monitoring facilities and data to the greatest possible extent. A combined approach, therefore, may require some additional investment to fill in data gaps but provides the greatest potential for meeting monitoring needs by bringing together a broad, multiple interest base of information. Of particular interest is data: 1) documenting existing hydrologic and water quality conditions; 2) defining ground-water flow systems; 3) describing hydrologic characteristics of aquifer material in order to predict fate of contaminants; and (4) providing support for decisions on sitings, facility design, and remedial measures.

In reviewing these approaches EPA considered the most practical way to gather information most useful for future decisions. Besides continuing to require monitoring under RCRA, Superfund, and the UIC program and conducting targeted surveys of ground-water contamination from surface impoundments and underground storage tanks, EPA will utilize existing monitoring facilities and data from all available sources (other Federal agencies, State and local governments, and other organizations) to achieve the most effective and efficient acquisition of monitoring data. This approach will be described further in a ground-water monitoring strategy the Agency is now developing.

3. CREATE A POLICY FRAMEWORK FOR GUIDING EPA PROGRAMS

EPA will adopt guidelines for consistency in its ground-water protection programs. The guidelines are designed to protect ground water for its highest beneficial use.

The Task Force recommended that EPA develop some agreed-upon guidelines for ground-water protection in order to have a basis for consistent decision-making among EPA programs. In considering what they should be, the Agency reviewed several approaches (Attachment IV) to answer two critical questions:

- What is the definition of the resource to be protected? Existing programs use different terminologies to define the resource they protect. It became clear that ground-water definitions are crucial to achieving consistency in protection.
- To what level should EPA protect the resource? The Agency considered whether all ground water, regardless of its use and value, should be protected equally. It reviewed whether EPA should give a higher degree of protection to ground water that is more valuable to society, and less protection to ground water that does not now (and is unlikely in the future) to serve as a source of water for drinking or for another valued purpose (e.g., irrigation, livestock watering, or industrial use).

The Agency considered a number of factors in this review. First, it studied the statutory base within which all EPA programs must continue to operate. Above all else, the requirements of existing law must be fully implemented. Second, the Agency reviewed the characteristics of the resource itself. Ground water is much more expensive to monitor, clean up, and protect than is surface water or air. This resource is vast, hidden, and a proportion is already unusable due to natural contaminants (usually aquifers with high salt concentration). In some circumstances, full cleanup of existing contamination is beyond the capability of existing technology. Its slow movement, however, means that most pollution remains highly localized, which facilitates management of known contamination. Some ground waters are much more valuable than others because they are the exclusive source of drinking water for a population.

Finally, the Agency considered the fundamental purpose of any environmental program: to protect public health and the environment. EPA concluded that the policy that must guide its efforts must be based on the recognition of the highest beneficial use to which the ground-water resource can presently or potentially be put. In this context, EPA has concluded that the protection of particularly sensitive and valuable ground waters is of critical importance. For this reason, EPA will use its authorities to the extent possible to provide the added protection that these unique, highly important resources deserve. The guidelines for ground-water protection reflect these considerations.

Guidelines for Ground-Water Protection

EPA's guidelines for ground-water protection are based on the beneficial use criterion described above. Protection policies are defined for three classes of ground water. The class definitions reflect the value of the ground water and its vulnerability to contamination, and they apply to ground water having significant water resources value. The three classes are: I) Special Ground Water, II) Current and Potential Sources of Drinking Water and Water Having Other Beneficial Uses; and III) Ground Water Not a Potential Source of Drinking Water and Having Limited Beneficial Use. These guidelines establish the basic framework for the Ground-Water Protection Strategy.

In describing the various classes of ground water, emphasis is on broad definitions and basic criteria to be used in class assignment. Guidance will be developed establishing more specific criteria and definitions for classifying ground water. This guidance may prescribe additional criteria to be used in identifying the various classes. It may also describe specific information necessary to make a determination of hydrogeologic vulnerability, such as geologic setting, hydrogeologic characteristics, climate, and physiography. EPA will work closely with States, local governments, business and industry, environmental groups, and other Federal agencies, particularly the DOI, in the development of this guidance.

Class I - Special Ground Waters

Certain ground-water resources are in need of special protective measures. These resources are defined to include those that are highly vulnerable to contamination because of the hydrogeological characteristics of the areas under which they occur. Examples of hydrogeologic characteristics that cause ground water to be vulnerable to contamination are high hydraulic conductivity (Karst formations, sand and gravel aquifers) or recharge conditions (high water table overlain by thin and highly permeable soils). In addition, special ground waters are characterized by one of the following two factors:

(1) Irreplaceable source of drinking water. These include ground water located in areas where there is no practical alternative source of drinking water (islands, peninsulas, isolated aquifers over bed rock) or an insufficient alternative source for a substantial population; or

(2) Ecologically vital, in that the ground water contributes to maintaining either the base flow or water level for a particularly sensitive ecological system that, if polluted, would destroy a unique habitat (e.g., those associated with wetlands that are habitats for unique species of flora and fauna or endangered species).

In order to prevent contamination of special ground waters, EPA will use RCRA authorities to initially discourage by guidance, and will eventually propose regulations to ban the siting of new hazardous waste land disposal facilities above these ground waters. EPA will in addition request information about the need to establish similar restrictions for some existing land disposal facilities. Further, for any existing hazardous waste land disposal facilities regulated under RCRA that continue to operate in these locations, EPA will at a minimum continue to require design practices to prevent contamination, and may consider adding special design or operating requirements. No discharge from such facilities will be allowed to contaminate the ground water so that background conditions or drinking water standards are exceeded. Where contamination has occurred within the facility boundary, EPA regulations require cleanup of ground water either to drinking water or background levels. EPA may also use its Superfund or imminent hazard authority to seek cleanup beyond the facility boundary if necessary.

The Superfund Hazard Ranking System will continue to operate under the current formula in selecting sites for designation on the National Priority List (NPL). The immediacy of the threat to Special Ground Water will be one of the factors for taking action among sites listed on the NPL. Cleanup objectives for such Superfund sites will also be to drinking water or levels that protect human health. Consideration of statutory factors (cost-effectiveness and fund balancing) and the need to achieve rapid privately-financed response may require occasional acceptance of lower levels of cleanup.

Under TSCA, EPA will evaluate the merits of developing additional restrictions on the use, disposal, or storage of potentially threatening chemicals over these areas. EPA will also apply the information-gathering authority under TSCA to learn more about the use, disposal, and storage of chemicals in these areas.

Under the UIC provisions of the SDWA, EPA will consider developing special permit conditions (e.g., special cementing requirements for casings going through special ground water, as well as monitoring of the ground water). EPA will also use the combined authorities of the Sole Source Aquifer (SSA) program and the National Environmental Policy Act (NEPA) to review Federally-financed projects to ensure protection of these special ground waters.

Class II - Current and Potential Sources of Drinking Water and Water Having Other Beneficial Uses

All other ground water currently used or potentially available for drinking water and other beneficial use is included in this category, whether or not it is particularly vulnerable to contamination. This comprises the majority of usable ground water in the United States.

As a general rule, Class II aquifers will receive levels of protection consistent with those now provided for ground water under EPA's existing statutes. This means that prevention of contamination will generally be provided through application of design and operating requirements based on technology, rather than through restrictions on siting, though exceptions may apply. Cleanup of contamination will usually be to background levels or drinking water standards, but alternative procedures may be applied for potential sources of drinking water or water used for agricultural or industrial purposes. EPA recognizes that in some cases alternatives to ground water cleanup and restoration may be appropriate. In these cases the contamination may be managed in order to avoid migration into a current source of drinking water or to avoid widespread damage. More specifics for each program area are defined below.

Under RCRA, prevention of contamination may include siting restrictions for new land disposal facilities over current sources of drinking water in areas highly vulnerable to contamination. These restrictions would initially be instituted through guidance and later through regulations.

Where ground water is used now for drinking water, cleanup of contamination from new and existing facilities will be subject to current requirements under RCRA, with cleanup to drinking water standards or background, as appropriate. For sites which can impact potential sources of drinking water or ground water used for other beneficial purposes, the same policy will generally apply. Alternate concentration limits (ACLs) now provided in the RCRA land disposal regulations will continue to be available for both current and potential sources of drinking water if the criteria for the ACLs can be met by an applicant. In addition, for ground waters not used as current sources of drinking water, EPA will also consider regulatory changes to allow variances in cleanup that take into account such factors as the probability of eventual use as drinking water and the availability of cost-effective methods to ensure acceptable water quality at the point of use. Other factors such as yield, accessibility, and alternative sources will also be considered.

The superfund hazard ranking system is more likely to place a site on the National Priorities List when the ground water which is contaminated or threatened with contamination is a current source of drinking water than when it is an unused potential source. Additionally, when remedial action is considered at a site on the NPL, such considerations as technical in feasibility, statutory fund-balancing provisions, and potential for adverse public health impacts may make cleanup of the resource less likely for potential sources of drinking water than for current sources. In certain situations involving current sources of drinking water, such as when technical feasibility is an issue, the cost-effective remedy may be to provide an alternate drinking water supply rather than restoring the contaminated aquifer. In these situations monitoring of the plume of contamination would be used to evaluate the need for further action to prevent or mitigate migration of the contamination.

EPA has identified no specific changes in policies under TSCA at this time. At a minimum, TSCA information gathering authority may be used to gather additional data on ground-water contamination potential of particular chemicals.

The UIC Program will apply its current provisions to Class II waters. Where the potential is low for ground water to be used as drinking water (for example, when TDS levels are between 3,000 and 10,000 mg/L, mineral production is a competing use, or the aquifer is inaccessibly deep), EPA will apply existing UIC requirements to a Class II aquifer.

Class III - Ground Water Not a Potential Source of Drinking Water and of Limited Beneficial Use

Ground waters that are saline or otherwise contaminated beyond levels which would allow use for drinking or other beneficial purposes are in this class. They include ground waters (1) with a TDS level over 10,000 mg/L, or (2) that are so contaminated by naturally occurring contaminants or by human activity (unrelated to a specific hazardous waste land disposal site) that they cannot be cleaned up using methods reasonably employed in public water system treatment. In addition, the ground water must not be connected to Class I or Class II ground water or to surface water in a way that would allow contaminants to migrate to these waters and potentially cause adverse effects on human health or the environment.

Prevention of contamination may be less than that provided for Class I or II in some instances, but high levels of protection will still be required in other cases. New and existing hazardous waste land disposal facilities regulated under RCRA will be required to meet the same technical standards -- such as liners, leachate collection systems, and monitoring -- as facilities located over Class I or II ground water. Hence, in terms of protection, the Ground-Water Protection Strategy currently envisions the same technical standard of protection for hazardous waste facilities in all classes. With respect to cleanup, should the hazardous waste facility leak, the Agency would normally grant variances that establish elevated concentration limits. Generally, cleanup decisions for Class III ground water that has been contaminated by human activities would be evaluated on a case-by-case basis. If contamination poses no risk to human health and the environment, as will frequently be the case (because the ground water is not usable and there are controls to ensure it is not used), then, under RCRA, cleanup requirements could be reduced or eliminated. Under other statutes, such as CERCLA, cleanup decisions may consider also the cost of the cleanup.

The Superfund program will not focus its response activities on cleanup of ground water in this class, although priority for taking Superfund actions may be given to sites over Class III ground water to control hazards unrelated to ground water (e.g., air emissions, fires, etc.).

Current UIC exemptions will remain in place, given the exemption provisions noted in Class II. Nutrient reuse and recycling requirements under the CWA will also follow these guidelines.

Implementation of the Guidelines for Ground-Water Protection

The purpose of these guidelines is to improve the consistency and effectiveness of EPA's current ground-water programs. Implementation of the guidelines requires translating the guidelines into specific requirements in each of the Agency's major program areas. This involves: (1) criteria and procedures for making decisions related to ground water according to quality, use, and vulnerability; and (2) changing existing regulations if necessary or possibly developing new regulations or guidelines that will result in "consistent" levels of protection in each program. These regulations will then provide the legal basis for the implementation of the guidelines. It is not intended that any substantive or procedural rights are provided by this strategy.

Even with the guidelines in place, certain inconsistencies among EPA programs will remain to be resolved and others will emerge. One major responsibility of the new EPA Ground-Water Protection Office (described below) is to identify and work with all EPA programs involved to resolve remaining issues of program inconsistency.

Many of EPA's programs are delegated to the States. For most programs, States must demonstrate that their programs are "no less stringent" than the Federal program in order to qualify for authorization to implement the programs. While EPA will foster State efforts to classify ground water in a manner consistent with the framework presented in this strategy, EPA will not require States to adopt the Federal classification scheme for their overall ground-water protection programs and will provide as much flexibility as possible under existing statutes to the States in implementing delegated EPA programs. Consequently, EPA will to the extent possible keep regulatory requirements based on EPA's ground-water protection guidelines general and performance-oriented. EPA will develop guidance to accompany such regulations for use by EPA when EPA directly administers a program in a State (e.g., implementation in a non-delegated State or implementation of a program which cannot be delegated). The guidance could also be used by the States to assist them in developing their own regulatory requirements or guidelines.

For EPA-administered programs, the task of actually determining whether the ground water in a particular location fits the criteria for Class I, II, or III will be a site-specific determination. In programs involving permits, such as RCRA and UIC, for example, this determination will be made during the permitting process based on data supplied by the permit applicant. In cleanup actions under CERCLA, the ground-water class will be determined in conjunction with the assessment of the extent of contamination. In many cases, the geologic and hydrologic information necessary to make these classifications will have to be gathered as a part of the site investigation. In other cases, ground-water studies already completed by other Federal or State agencies may sufficiently describe hydrogeology such that the ground-water classification decision will be greatly expedited. Where States have already mapped or designated ground-water classes for that location, the State classification of the ground water may be sufficient where it is comparable to these guidelines.

4. STRENGTHEN INTERNAL GROUND-WATER ORGANIZATION

During EPA's review of its ground-water programs, it became evident that the Agency could not go forward with an enhanced ground-water protection effort, or provide leadership to the States in achieving coordinated protection of the resource, without clearly designated responsibility and adequate staff support.

There is a continuing need to coordinate EPA programs within this common policy framework, and there must be effective support to States seeking to manage their ground-water resources. A strong and supportive research effort is a crucial element. These tasks require an internal management structure, within which the several EPA programs with ground-water protection responsibilities can function in an orderly, mutually supportive way.

The Agency considered several options for increasing its own institutional capability at the Headquarters and Regional levels (see Attachments V, VI and VII). The major concern was to establish this capability without the substantial disruption that reorganization would involve. For that reason, the Agency will retain ongoing program efforts in their current organizational locations, assigning lead responsibility for ground-water coordination to the Assistant Administrator for Water, and locating lead responsibility in the counterpart divisions of the Regional offices.

In order to carry out this mandate, the Assistant Administrator for Water has been directed to:

- Establish an Office of Ground-Water Protection;
- Convene and chair an oversight committee of Assistant Administrators and two Regional Administrators; and
- Establish an ongoing dialogue with State program directors.

The Office of Ground-Water Protection (OGWP) was established on April 2, 1984. It will have responsibility to provide staff support to the AA/RA Oversight Committee. This committee will provide policy oversight and direction to the Office in the implementation of the Ground-Water Protection Strategy. It will ensure coordination of all EPA ground-water activities, identify and direct the development of ground-water policies and guidelines, and coordinate activities of program offices to carry out the Agency ground-water Strategy. The Office will also convene a "Ground-Water Steering Committee" to review all ground-water policies and regulations and make recommendations on all budget requests for ground-water protection activities. This committee will be composed of office directors with operating responsibilities for ground-water protection and several water division directors. Special attention will be given to coordinating research priorities to support State and EPA ground-water protection programs, and to planning future actions as experience is gained.

OGWP will also work with Regional ground-water offices, providing policy contact and program coordination, including developing guidance for use of grant funds to support State program development. It will provide guidance to Regions, and develop information for Regional use in providing technical assistance to the States, such as on data management techniques and State program development.

Data management and EPA research coordination will also be addressed. Over time OGWP will develop information on how to access available ground-water data for use by Regions, States, and site managers. It will identify new data needs, identify data needed to determine long-term trends and status, and conduct or initiate special studies of ground-water contamination.

Further, the Office will be responsible for assessing and evaluating how effective EPA has been in implementing the ground-water strategy -- such as in Regional coordination, steering committee effectiveness, State program development and implementation -- either directly or by arranging for an outside reviewer. The Office will also work with other program offices to assess the effectiveness of ground-water quality management and clean up activities, such as remedial action and site cleanup, and to support demonstrations of successful State ground-water program operations.

OGWP will work with other Federal agencies, such as U.S. Geological Survey (USGS), Department of Defense (DOD), Department of Energy (DOE), Department of the Interior (DOI), Nuclear Regulatory Commission (NRC), and U.S. Department of Agriculture (USDA), as well as with relevant outside interests, such as State organizations, trade and industry groups, environmental groups, the press, Congressional staffs, and others. It will convene an Interagency Committee on Ground Water consisting of individuals from Federal departments and agencies having ground water concerns. This committee will meet several times during the year to exchange information of mutual interest. Other committees will be established as needed. The Office will serve as an Agency spokesperson on legislative matters affecting ground water.

Regional responsibility for ground-water coordination and management will generally reside in the water divisions. In order to permit Regional flexibility, yet achieve adequate consistency among Regional programs, EPA has developed general criteria for Regional ground-water programs.

Functions for a Regional ground-water program include the development and oversight of ground-water policy development and coordination. Regions will establish an enhanced effort to provide States with technical and institutional support in developing ground-water programs and strategies. Regional ground-water protection offices will coordinate Regional ground-water programs such as State work programs, Regional program plans, site assessments, and enforcement. They will coordinate the ground-water data collected by Regional programs, and they will develop, with the States, systems for making data from various sources accessible to groundwater managers. They will also be responsible for coordinating related Regional training, technical assistance, and public response.

While each Regional organization will be somewhat different depending on the particular needs of the Region, each Regional organization should provide for a mechanism for full participation of all Regional ground-water programs at a level where decisions can be made and a mechanism for issue resolution by the Regional Administrator or the Deputy Regional Administrator. Each should include a full-time director and full-time support staff with technical, managerial and intergovernmental skills.

The organizational structure to be established at the EPA Headquarters and Regional levels should make a major contribution to the coordination of EPA programs and the support of State ground-water protection efforts.

* * * * *

In summary, this EPA Ground-Water Protection Strategy represents a major step forward in EPA and State efforts to protect ground water. The strategy has four goals:

- To foster stronger State government programs for Ground-Water Protection:
  - -- EPA will provide grant support for State program development;
  - -- EPA will offer technical assistance to States; and
  - -- EPA will target research efforts to State requirements.

- To cope with inadequately addressed problems of ground-water contamination:
  - EPA will assess the extent of contamination by leaking underground storage tanks, issue a Chemical Advisory warning gasoline station owners and operators of the problem, and consider the need to further regulate these contamination sources;
  - EPA will assess the problems associated with surface impoundments and landfills; and
  - EPA will strengthen its efforts to protect ground water from pesticide contamination and over time assess the effects of other practices on ground-water quality.
- To establish a framework for decision-making by EPA programs:
  - EPA will adopt guidelines for ground-water protection. These guidelines will assure a high level of protection for ground water used for drinking and other beneficial purposes, and bring about greater cohesion in EPA ground-water protection efforts.
- To strengthen the internal ground-water organization
  - EPA has established an Office of Ground-Water Protection in the Office of Water and counterpart offices will be established in each Region.

EPA believes that this strategy represents a pragmatic, evolutionary approach to improving the protection of the Nation's ground-water resource. It will provide the institutional muscle needed to bring about the needed change. It provides at the Federal and State levels a framework for decision-making and a roadmap to address new problems. This Strategy can only be successful through EPA leadership, the development of strong State programs, and general support from Congress, environmentalists, and the regulated community.

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INTRODUCTION

This section contains three types of materials as background information.

1. Attachment I is a chart which describes the various functions agencies perform at the State, Federal and local levels to protect ground water.
2. Attachment II is a more detailed comparative analysis of EPA ground-water regulations than is provided in the text of the Strategy.
3. The last three appendices are summaries of the principal options EPA considered in the development of this Strategy.

ATTACHMENT I

STATE/LOCAL/FEDERAL GROUND WATER ROLES

Role	State	Local	Federal
Direct Implementation			
Includes: All activities which directly affect individual sources of pollution, e.g., regulatory and enforcement action; product registration, emergency response and policy development	• The principal role of Ground Water Resource Management	• Local strategies	• Implement Federal Programs where States have not assumed delegated responsibility
	• Implement Federally delegated programs	• Local ordinances	• Product controls, bans, etc. under TSCA, FIFRA
	• Establish State source controls	• Land use and development controls	• Superfund Trust Fund: Clean up and manage contamination
	• Manage contamination sites	• Site management	• Emergency response under various statutes
	• Emergency response	• Emergency control	• Oversight of Federal program management and enforcement
Technical Support			
Includes: Development and provision of assistance or support to outside groups; purpose is to ensure success of State programs	• Technical assistance on site control and management, ground water protection	• Public education and technical assistance	• Specialized: Health Advisories, biochemistry, hydrogeology, special problems in such areas as: laboratory testing
	• Techniques, program management, etc.		• General; institution building, program development, program guidance
			• Scientific: Transfer of new science/technologies

ATTACHMENT I - Pg. 2

STATE/LOCAL/FEDERAL GROUND WATER ROLES - continued

Role	State	Local	Federal
State Program Approval and Oversight			
Includes: Grant approval process, audits and evaluation of State programs	• Participation in criteria development	•	• EPA Lead
Standard Setting			
Regulations, rules, and standards for EPA statutes	• State standards for Federally unregulated contaminants and, where the State prefers more stringent State standards	•	• EPA has primary lead, e.g., - Drinking water standards - Technology based standards - Other ground water program standards
Research			
Includes: All activities that produce information improving the scientific or technical bases for making decisions at all levels of government	• Conduct some research, usually associated with specific sites • State GS define aquifers - State mapping and inventorying	•	• EPA lead, e.g. fate, effects, monitoring technology, health effects • USGS primarily provides data on hydrogeology, hydrology and geochemistry

ATTACHMENT I - Pg. 3

STATE/LOCAL/FEDERAL GROUND WATER ROLES - continued

Role	State	Local	Federal
National Information Collection			
Includes: Data on quality of ground water and related data	• States collect data for state and local purposes and participate in Federal data collection via delegated programs and special studies	• Participate in data collection	• EPA provides: - monitoring data - source inventories - special studies • USGS provides information on hydrogeology, hydrology and geochemistry
Funding of State Programs			
Includes: Operating expenses for State environmental programs	• States provide extensive support directly	• Some local areas provide funds dedicated to ground water protection	• EPA provides support to States through RCRA, UIC, and CWA grant programs and support for site clean up via Superfund • USGS povides support through its Federal/State Cooperative Program and through other basic and applied research programs.

SUMMARY OF EPA GROUND WATER REGULATIONS

DEFINITION OF RESOURCE - LIMITING FACTORS

	General Scope	Quantity	Quality	Use	Other
RCRA 264	Aquifers, i.e., yield significant amounts of water				Monitoring only occurs in uppermost and inter-connected aquifers
RCRA 257	Aquifers, i.e, yield useable quantity of water		10,000 mg/l TDS unless currently used		Point of application of std. may be moved if aquifer not used or needed
SDWA UIC	Aquifers, i.e., yield significant quantity of water	Sufficient to supply public water system (PWS)	10,000 mg/l TDS unless currently used	Potential to supply a PWS unless currently used	Exempted aquifer variance:* not curently used and not a potential source of drinking water because it is: o Mineral, hydrocarbon or geothermal energy producing; o Too deep to make recovery for drinking water practical; o So contaminated that it is impractical to make ground water fit for drinking; or o Located over a mining area subject to collapse
CERCLA NCP/NPL	Ground water(i.e., water in saturated zone beneath surface of land or water)	Extremely low yield NPL score = 0	Extremely saline NPL score = 0	Differing NPL score based on uses of ground water (drinking water, commercial, industrial irrigation) and number of people using aquifer	NPL score = 0 if: o Nearest well 3 mi. o No CW contamination and water table 150 ft. or soil permeability 10^{-7} cm/sec

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* An aquifer does not become an exempted aquifer until EPA has approved such a designation.

TABLE 1

DEFINITION OF RESOURCE - LIMITING FACTORS (continued)

	General Scope	Quantity	Quality	Use	Other
UMTRCA	Same as Part 264				Same as Part 264
TSCA-PCB	Ground water (undefined)				
CWA Construction Grants	Ground water (undefined)			3 classes based on current and potential use	
High Level Rad. Waste	Ground water(i.e., saturated zone)				Only GW beyond 10 km from waste. Fate of GW within 10 km considered in EIS
FIFRA Pesticide Policy	Ground water(i.e., saturated zone)				

TABLE 1
Page 2

ACCEPTABLE LEVEL OF CONTAMINATION

BASIS FOR DEFINING ACCEPTABLE DEGRADATION

	Constituent of Concern	No Degradation	Numerical Standard	Other
RCRA 264*	Hazardous constituents = list of 387 chemicals (including organic and inorganic constituents in NIPDWR)	HW constitutents: no increase over background NIPDWR: no increase if ambient exceeds MCLs	No violation of MCLs	Risk-based alternate concentration limit on a case-by-case basis
RCRA 257	Organic and inorganic constituents in NIPDWR	No increase if ambient exceeds MCLs	No violation of MCLs	
SDWA UIC	Fluids	Class I, II, III: No movement into USDW's (design standards)		
	Constituents in NIPDWR		No violation of MCLs	
	Contaminants not in NIPDWR			No adverse effect on health of persons
CERCLA NCP/NPL	The HRS scores the "most hazardous" constituents			HRS scores rely on Sax, NFPA Toxicity. Final level of cleanup is based on cost-effectiveness (defined to include adequate protection of public health, welfare, environment) and on preservation of Fund.

* The RCRA interim status rules (Part 265) establish no acceptable level of contamination. No action is required unless monitoring detects contamination.

TABLE 2

ACCEPTABLE LEVEL OF CONTAMINATION

BASIS FOR DEFINING ACCEPTABLE DEGRADATION

	Constituent of Concern	No Degradation	Numerical Standard	Other
UMTRCA	Same as part 264+ Radiological constituents in NIPDWR and Molybdenum and Uranium	No violations of MCLs which include: Radium 226/.228 5pCi Gross alpha 15pCi		
TSCA PCB	PCBs, pH, specific conductivity, chlorinated organics		Monitoring only No specified limits	
CWA Construction Grants	Current Drinking Water: all construction in NIPDWR	No increase if ambient above MCLs	No violation of MCLs	Microbiological limits for water used without disinfectants
	Potential Drinking Water: organic and inorganic in NIPDWR	No increase if ambient above MCLs	No violation of MCLs	
	Other uses	Case-by-case decision based on present or potential use.		
High Level Rad.Waste	Reasonably foreseeable releases from: 1. 14 specific radionuclides 2. other alpha-emitting radionuclides 3. any other radionuclide		1. limits for each constituent 2. 10 curies/ 1000 metric tons of heavy metal (MTHM) 3. 500 curies/ 1000 MTHM	
	Very unlikely releases from above		10 times above standards	
FIFRA Pesticide Policy	Pesticide under review		Maximum advisable level no effect on 10kg child drinking 1 liter/day	FIFRA must also consider risks and benefits of pesticide use in deciding upon appropriate controls

TABLE 2
Page 2

REGULATORY MECHANISMS

	Technical Requirements	Environmental Performance Stds.	G-W Monitoring	Location	Remedial Action	Other
RCRA 264*	Standards for design, construction operation, closure, post	Ground water protection std. specified once facility leaks	For land disposal facilities: number/location; frequency; waivers possible	No waste management in a few areas e.g. flood plains/seismic zones; Variance possible	When needed to return to compliance with GW protection standard/treat or remove	
RCRA 257		GW performance				
SDWA UIC	Class I,II,III: - construction, operation, closure standards - plugging adjacent wells that may allow movement of fluid	Class I,II,III,V: non-endangerment USDWs	At discretion of permit writer			Ban on HW injection into USDWs
NCP NPL	Case-by-case decision under NCP could include any of these approaches					
UMTRCA	Liners closure requirements	Similiar to Part 264	Case-by-case decided by NRC		Similiar to Part 264	

*/ Interim status regulations (Part 265) include many of the same standards. They do not include a ground-water protection standard or a corrective action requirement.

TABLE 3

REGULATORY MECHANISMS -continued-

	Technical Requirements	Environmental Performance Stds.	G-W Monitoring	Location	Remedial Action	Other
TSCA PCB	Construction, operating, monitoring standards		At all facilities: number/location parameters	-50 ft above water table -not in recharge zone		
CWA Const. grants	Best practicable waste treatment technology	Case-by-case usually NIPDWR constituents	Required if needed to show			
High Level Rad. Waste	Design performance std.					
FIFRA Pesticide Policy	Uses labels to impose applicate rates through individual lisencing decisions		Can impose monitoring requirements on registrants if leaking is a potential concern	Uses lables to impose geographical restrictions, logoffs, etc.		Decision to cancel register pesticide

TABLE 3

ATTACHMENT III

State Assistance

Options	Implications
- Create a new grant program to provide broad State support for ground water	- Would increase support to States for program development, control of non-federally regulated sources of contamination - Would require a new grant authority and major new funds
- Provide support to States for program development	- Would increase capacity for problem assessment, strategies, system design; institutional coordination - Possible through existing authorities, e.g., CWA, 205(j), RCRA, UIC
- Provide increased funding and scope of authority to existing federally delegated State programs	- Increased grant support underway through regular budget channels - Expanded use of existing authorities

ATTACHMENT IV

Options for Ground Water Protection Guidelines

1. What is the extent of the resource to be protected?

Options	Implications
- As measured by quantity	- "Significant" yields have never been defined, e.g., intrinsic value (< 1 gpm are not aquifers) or relative value (difference from wet to dry area).
- As measured by quality	- Varies by natural condition and human-made contamination - Generally defined based on total dissolved solids (TDS) - Some aquifers are pristine quality - Some aquifers are so contaminated they are unusable.
- As measured by location	- Some ground water, even relatively fresh is located at great depths making its economic use doubtful, particularly if plentiful surface water is available

2. To what level should EPA protect the resource?

Uniform Protection: - Nondegradation	- Perceived as goal for several States/EPA programs; tempered by waivers - Nondegradation is a practical impossibility - If fully implemented RCRA variances and UIC variances would have to be dropped; - Superfund theoretically would have to clean up every site regardless of NPL score.
- Protect to a given level	- Allow degradation to protect a given use, e.g., drinking water or other standard - Difficult to establish a comprehensive set of standards - Would require extensive changes to UIC and RCRA rules - Superfund would have to clean up to reach these levels
Differential Protection: - Classification	- Various classes based on current and future use of water - Either by mapping areas or case-by-case - Effluent standards, ban or restrict activities, engineering or management practices - Massive change for RCRA - different design and operating rules; also UIC/SF - States/localities would classify; expensive to implement
- Waivers and exemptions	- Approach now used by UIC/RCRA - Resource broadly defined; regulations allow for case-by-case determination - Could mesh with existing State classification - Least disruptive for UIC and RCRA
Broader Environmental Policy: - Site-by-site assessment	- Agency defines acceptable risk level, e.g., 10-6 risk level and use it to determine whether action should be taken or allowed; case-by-case - Would require scrapping much of current RCRA/UIC - Risk analysis time consuming, probably exceeds current science
- Best alternative option	- Evaluate range of alternatives and choose one that is least environmentally disruptive - Mirrors NEPA approach - Would require modification of all existing regulations

ATTACHMENT V

Headquarters Coordination Options

Options	Implications
- Create an Office of Ground Water at the AA level (alternatively shift selected programs to one AA)	- Incorporate all ground water regulatory programs - Would provide consistent management, policy resolution, and need little guidance from which to operate - Would be highly disruptive and untimely - Would fragment existing programs where ground water is an integral part
- Give the lead to an Assistant Administrator	- Capability to undertake such an assignment - Coverage of ground water programs would be maximized by relying on a strong interagency coordinating office - Policy consistency and coordination is highly possible given a clear charge and sufficient resources - Could be started quickly with little disruption - Coordination across AAships sometimes difficult to achieve
- Establish a Standing Committee	- Similar to steering committee function of regulatory review and issue resolution could be initiated - Could be initiated quickly with little disruption - Committees usually have limited success in shaping operating programs
- Maintain current structure with no formal organization	- Rely on general Agency policy coordination structure, e.g., steering committee, budget reviews - Assign specific issues to program offices - Unlikely to obtain policy coordination

ATTACHMENT VI

Regional Management Options

1. What functions should be carried out in each regional office?

Options (Cumulative)	Implications
- Minimal effort: coordinate regional training, technical assistance and public response	- Possible within existing resources - This is the current minimal general effort - Little impact on program management and coordination
- Add capability to manage the nature, quality and accessibility of ground water data collected by regional programs; increased output to EPA research agenda	- Badly needed - Staff required - Little impact on direct program operations
- Add responsibility for oversight of State plans, program plans, and coordination of site assessment and enforcement	- Would assure operating regional programs are coordinated - Depending on level of authority of decision-making, could have substantial impact on program operations - Resources required
- Add responsibility for developing and overseeing regional ground water policy development and coordination	- Would greatly increase Regions' ability to assure policy consistency among its programs
- Add responsibility for a greatly enhanced regional effort to provide States technical and institutional support in developing ground-water plans and strategies	- Would be a substantial component in effort to assist States increase their ground water protection efforts - Require staff knowledgeable in program development and institutional arrangements, and ground water science and technology

Farm Water Poisons Wildlife

California Refuge Contaminated

By Cass Peterson
Washington Post Staff Writer

LOS BANOS, Calif.—Snow geese circle, rise and circle again before settling in a greening meadow. A blue heron glides low over a dark pool framed by bronze cattails.

There is silence except for the riffling water and the rustling reeds. And the popguns, testament to good works gone awry.

The government's propane guns, noisy but harmless, boom across the Kesterson National Wildlife Refuge here every few minutes, scattering ducks, herons and geese to flight from a placid reservoir that has become a deathtrap.

Birds that disregard the guns and nest here produce grotesquely deformed offspring—chicks without eyes, without legs, with twisted wings, contorted beaks, and brains protruding through malformed skulls.

Kesterson is contaminated with selenium, a naturally occurring element now dangerously concentrated in the waters of the refuge as a byproduct of the way man has rerouted water across this state for purposes of agriculture.

For years vast amounts of water have been brought from the north to the San Joaquin valley south of here; a desert has been trans-

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formed into one of the nation's richest agricultural areas. But because the valley has an impermeable floor, the water could not escape until the government also built a drain, a ditch back to the north.

That ditch now ends in the refuge, carrying not only used water but salts and minerals leached from the valley's soil. The selenium is one of these.

Once a haven for egrets, white cranes and grebes, the refuge now lies at the heart of the latest controversy over the water-intensive farming practices of central California. The battle this time is over repairs, whether to stop the irrigation water, find some way to treat it or find some other place to put it—and who will foot the multibillion-dollar bill.

Farmers here, confident that Washington will not turn its back on the cornucopia that it created, say they expect the Treasury to come to their rescue.

The drainage ditch, called the San Luis Drain, was not intended to end here. If completed, at a cost estimated at nearly $5 billion, the drain would carry Kesterson's selenium-laden water to the watershed above San Francisco Bay, from which the state pumps drinking water south to Los Angeles.

"The only way to stop producing the water is to stop irrigating the land," said William Johnston, manager of the Westlands Water District, the largest importer of water in the western San Joaquin valley. "If the land can't be drained, it will go out of production."

Federal officials say the cheapest way to clean up Kesterson would be to close it, and the San Luis Drain as well, with "serious adverse economic consequences" for the valley's farmers. More than 40,000 acres of farm land would go out of production, according to the Interior Department.

But farmers here contend that the impact would be far greater, potentially threatening more than 1.5 million acres in the western San Joaquin.

The valley's agricultural interests have come up against the formidable problem of toxic waste. And the farmers' traditional foes, armed with the stark evidence of the polluted reservoir, are determined to make Kesterson a symbol of what they view as the folly of national water policy in the West.

"I don't want to say it's insoluble," said Albert Meyerhoff, an attorney with the Natural Resources Defense Council. "But there's going to be a significant economic crunch. And a good part of the land that has been put into production may well have to be taken out."

Bill Davoren, a former Interior Department official who heads the Bay Institute, a San Francisco-based conservation group, is more direct.

"They should have known better than to put good river water in there to start with, and they're going to have to start relocating that water to land that is not so mineralized."

At the root of this dilemma is geology. The San Joaquin valley's western slope, blessed with a benign climate and fertile ground, is considered prime farm land. By the measure of productivity and price, it is. Land goes for $3,500 an acre and produces, with the help of irrigation, up to three times the yield of non-irrigated lands elsewhere.

But the soils are laced with the salts and minerals of the sea bed it once was, and the vast, flat fields are underlaid by impermeable clay.

Add irrigation water and the land blooms—for a time. As water pools above the clay, the soil becomes saturated. The rising water table drowns roots and pushes salt to the surface in crusty white patches.

"They've got a flowerpot without a hole up there," Davoren said.

The federal Bureau of Reclamation, which designed and built the massive Central Valley Project that waters the western San Joaquin, anticipated the need for drainage and 30 years ago set about to create a hole for the flowerpot.

In the 1960s, with political help from the area's well-connected farmers, the bureau persuaded Congress to approve $700 million for the San Luis Drain. The drain was envisioned as a 200-mile canal that would carry waste water back north.

The money ran out in 1975, with the drain more than 100 miles shy of its eventual drainage point in the Sacramento-San Joaquin delta above San Francisco. The terminus was the Kesterson reservoir, a 1,200-acre complex of ponds that was set up to do double duty as a wildlife refuge and a regulating reservoir for the drainage system.

For several years, while the bureau laid drain pipes under farm land, the reservoir was filled with fresh irrigation water from the Delta-Mendota Canal. Then, in the late 1970s, farmers began laying drainage tiles under their fields and hooking them into the San Luis Drain.

Waste water began to flow into Kesterson, with dramatic effect.

Gary Zahm, who came to Merced County in 1981 to manage the Kesterson refuge and other federal wildlife preserves in the western valley, said he knew immediately that something was amiss in the reservoir.

"I didn't see the diversity of life. I didn't see muskrats, crayfish, turtles," he said. "After 18 years of working in marshes, it just didn't look right."

Only tiny mosquito fish remained in the brackish waters.

Zahm, suspecting something akin to a pesticide spill, called in a team of biologists. The verdict came in December 1982: Sediment from the reservoir was contaminated with concentrations of selenium more than twice what would qualify it as hazardous waste under federal law.

Water showed selenium at levels up to 4,200 parts per billion, more than 400 times the level considered safe for drinking. The mosquito fish showed the highest concentrations of selenium ever found in living creatures—up to 53 parts per million.

At the same time, biologists started finding deformed nestlings, evidence that selenium was working its way up the food chain.

"That was the first indication anybody had that there would be a problem with the drainage water," Johnston said. But more tests showed that the problem was not confined to Kesterson.

Farmers and federal officials had studied the drainage problem here for decades, mainly concentrating on salts and boron, another abundant mineral that at high concentrations can damage plants.

But somehow selenium escaped notice.

"We knew when we imported the water this would happen," said Dan Nelson, manager of the Broadview Water District, one of 30 irrigation districts in the western valley. "We all thought Kesterson was as efficient as hell. But we didn't know about the selenium. We had enough problems without the selenium."

Last month the state Water Resources Control Board gave the Bureau of Reclamation five months to design a cleanup plan for Kesterson and three years to put it into effect.

The bureau argued that the situation cannot be corrected so quickly.

Alternatives to the San Luis Drain have been suggested, but most of them involve even more expensive strategies (such as desalinization) or alternate dumping sites that have political opponents.

At one time, farmers thought of draining their waste water into Nevada's Mojave Desert, but the selenium discovery has stiffened resistance there. Another possibility is ocean discharge near Monterey, Calif.

"The real hard fact is that by adopting this order the board may force 42,000 acres of prime agricultural land out of production," bureau regional director David G. Houston told the board.

Three thousand of those acres belong to Darrell Silveira, who grows cotton, sugar beets and alfalfa in the western San Joaquin. Silveira's farm was one of the first to need drainage.

"My grandfather took this land out of sagebrush," he said. "Now, just one phone call and I'm bankrupt."

There is no denying the benefits that imported water has brought Silveira. He pays $21 for enough water to flood an acre the depth of one foot, and he uses about 9,000 acre-feet a year.

But the real cost of that water is $53 an acre foot, according to Silveira, which means the federal government subsidizes his irrigation at the rate of more than $280,000 a year.

Silveira and other farmers here contend that they cannot afford to dispose of the excess water.

"We might have to go to the taxpayer for some help," district manager Nelson said. "That's not out of line, given the advantages the taxpayer gets from irrigated agriculture."

Adds Silveira: "If there's no other solution but to put me out of business, I can accept that. But to cut off the ocean for disposal would condemn agriculture as we know it."

To residents of smokestack cities, Silicon Valley
has it all—a fast-paced economy, an enviable lifestyle,
and fantastic weather. Just don't drink the water.

HIGH-TECH POLLUTION

Silicon Valley—as the belt of industrial suburbs at the southern edge of San Francisco Bay is widely and aptly known—is the home of America's booming high-technology electronics industry. Governors, mayors, and chambers of commerce throughout the United States see Silicon Valley as a model for reindustrialization, in which clean, light, "sunrise" industries replace heavy, dirty, "smokestack" industries as the cornerstone of American economic prosperity.

It's easy to see why the electronics industry has developed a "clean" image. Its well-landscaped factories resemble modern college libraries. Production takes place in "clean rooms" where the air is filtered and the workers wear surgical gowns. Electronic products don't breathe exhaust or drip oil, and in many applications, such as automobile engine control, microprocessor chips actually lower energy consumption while reducing polluting emissions.

Appearances do not tell the whole story, however. On December 7, 1981, water officials quietly shut down a contaminated drinking well operated by the Great Oaks Water Company just 2,000 feet from an underground storage tank at Fairchild Semiconductor's plant in South San Jose. Officials estimated that 14,000 gallons of 1,1,1-trichloroethane (TCA), a degreasing agent used to clean silicon "chips" and printed-circuit boards, plus 44,000 gallons of toxic waste materials, had been leaking from the tank undetected for a least a year and a half. Fairchild officials explained that the liquid-level indicator on the 6,000-gallon tank had malfunctioned, and had been giving incorrect readings for years.

The public was not informed of the Fairchild contamination until seven weeks later, when an environmental reporter for the San Jose *Mercury News* broke the news to a startled public. When the plant's residential neighbors learned about the presence of TCA in their drinking water, they blamed the area's unusually high concentration of birth defects and liver and kidney problems on that exposure, and more than 200 people filed multimillion-dollar suits against the pioneering high-tech firm.

Industry leaders and government officials were "surprised" by the discovery of leaks. Before 1982 only a handful of activists in Silicon Valley had raised the issue of high-tech pollution, and their warnings had been largely ignored. The 1975 finding by the Environmental Protection Agency that trichloroethylene (TCE), a more toxic relative of TCA, causes liver cancer in laboratory animals raised few eyebrows among industry leaders, government officials, or the mass media. "At that time, there were so many things people didn't know," says Steve Heikkila, an engineer with the San Francisco Bay Regional Water Quality Control Board. "There was no reason then for industry officials to consider the possibility of a leak when they were thinking about siting."

LENNY SIEGEL

Illustrations by John Hersey

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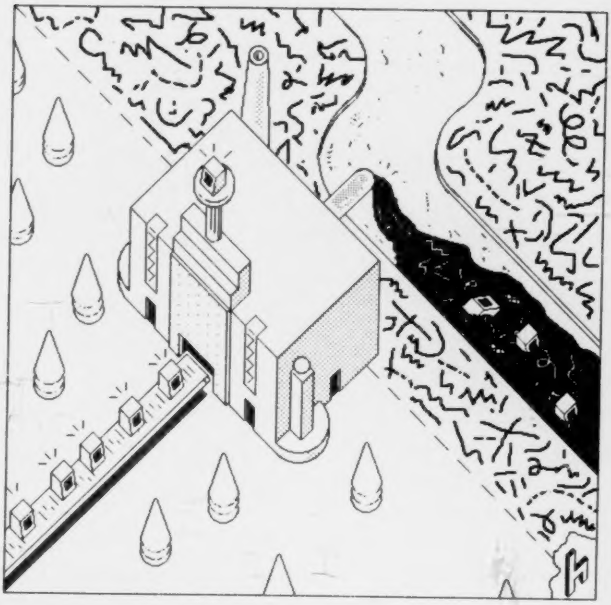


Silicon Valley residents were alarmed by the situation, and their alarm has only grown over time. Followup tests disclosed leaking underground containers at 65 of the 79 industrial sites being monitored in the valley. Tests of well water in Mountain View and South San Jose showed traces of contamination, a discovery that led to the shutdown of wells in those areas. In the wake of the Fairchild incident, many companies, concerned about the cost of lawsuits and cleanups, began to consider installing double-walled tanks resistant to leaks. As of this writing, Fairchild Semiconductor has spent more than $15 million to clean up a spill for which it has never admitted responsibility.

Not long after the Fairchild spill hit the front pages, fire chiefs from Santa Clara County's cities and fire districts met to develop a model ordinance that would help prevent future leaks, reduce chemical hazards, and ease their increasingly difficult job of responding to emergencies. Major electronics firms decided to cooperate and immediately asked to be represented. The chiefs welcomed five of the industry's trade associations into the task force, but did not invite labor, environmental, or other community groups.

In July 1982 the task force held its first "public" hearing, with no advance notice to the public. The chambers of the Sunnyvale city council were jammed with high-tech representatives, but also in attendance were about a dozen activists who had learned of the meeting by monitoring an industry-association newsletter. Their comments were not taken too seriously at the time, but led by the Central Labor Council of Santa Clara County, a regional branch of the AFL-CIO, they formed the Silicon Valley Toxics Coalition to keep the public informed and to organize support for the new measure.

The basic outline of the model ordinance was released at the July hearing. The proposed laws would require that all new underground tanks used to store hazardous chemicals include an outer, or secondary, container. Existing storage tanks, some located under buildings, could remain in place but would be monitored closely. If found leaking, they would have to be replaced with double-walled containers.

The electronics industry backed the principle of secondary containment and endorsed the proposed ordinance. Through its participation in the task force, the industry had won a large number of modifications designed to make compliance easier and less costly.

The Toxics Coalition turned out scores of people at a series of later hearings. By the time the model ordinance was hammered into final form several months later, the coalition had won strong language providing for public disclosure and protecting the rights of "whistle-blowing" employees; it also had fought off pressure from petroleum companies, which wanted to exempt gas stations from the ordinance. The county-wide Intergovernmental Council adopted the recommendations of the coalition, and virtually all Silicon Valley communities have enacted the model ordinance into law.

But the crisis is far from resolved. This past June, residents of the semirural North Bayshore area of the Silicon Valley city of Mountain View learned that they too had been drinking, bathing, and washing with private well-water contaminated by TCE, apparently originating from a leaking tank at nearby Teledyne Semiconductor. The levels of contamination found ranged from low concentrations to 400 times the "acceptable" level set by state officials. In addition, three electronics firms in nearby Sunnyvale were issued "cleanup and abatement" orders from the water board regarding leakage that is believed to have occurred at least two years ago. State officials believe the TCE spill has traveled at least 1,500 feet northward and now threatens private wells. All told, the water board in June reported at least 120 other locations where toxic solvents or gasoline are known to have leaked from underground storage tanks in the Bay Area, two thirds of which are in the Santa Clara Valley.

Soon after the discovery of contaminated drinking water in North Bayshore—the third such incident in Silicon Valley in three years—worried residents from Mountain View and Sunnyvale crowded into a church auditorium to hear experts explain the potential consequences of human exposure to the leaking chemicals. Anita Zimmerman, a former electronics worker suffering from on-the-job exposure to toxic chemicals, drew enthusiastic applause when she asserted, "Our health is worth more than anybody's profit margin, and our children are worth more than anybody's chips."

> *Officials throughout North America are touting their communities as Silicon Mountain, Silicon Beach, or Silicon Valley East, but few residents of the nation's many would-be "silicon" regions have heard about the hazards of high technology.*

Silicon Valley residents wondered why wells had not been tested for contamination in areas where leaks were known to have occurred. Teledyne reported its leak to the regional water board in November 1982, and the consultant who confirmed the leak warned in August 1983 that the plume threatened private wells in North Bayshore. Yet no one tested those wells for nearly a year.

According to the water board's Heikkila, who is working on cleanups in Mountain View and Sunnyvale, monitoring wells is an expensive and time-consuming project. "First we have to go through negotiations to persuade the companies to construct wells that will monitor the leaks," a process he says costs about $5,000 per well and up to $400 per sample of groundwater. "We want to minimize the cost to the companies but still be able to find the level of contamination. . . . Then we have to agree on where to put the initial monitoring wells. Some people ask why we don't put the monitoring wells way out to begin with. Well, the companies are often reluctant to put wells any farther from the leak than they have to; some don't want them outside their property lines. It's all a process of negotiation, and it takes time."

And time, according to Ted Smith, head of the Silicon Valley Toxics Coalition, is something the valley does not have. "We're sitting on a toxic time-bomb. Fortunately, the deep underground aquifer that stores and supplies water for the bulk of the valley's residents still appears clean. But these plumes of extremely dangerous chemicals are drifting around underground, seeking an abandoned agricultural well or some other quick path to our water supply. If that happens, the aquifer may be permanently poisoned."

It might appear that although chemical leaks in the valley have contaminated soil and groundwater within 50 feet of the Earth's surface, most public aquifers, which are 200 to 700 feet below ground, are safe. Yet one of the dangers peculiar to Santa Clara County is the literally thousands of private wells, many long-since abandoned and boarded up, that can carry toxic chemicals from shallow groundwater to deep public water sources. At present no one knows where all these wells are located.

In fact, there is still much that is not known about the extent of water contamination in Silicon Valley. According to Heikkila, leaks are "always turning up. People removing old tanks or installing new ones are constantly reporting leaks and the possibility of polluted groundwater. When we did the initial survey for leaks we hit the most likely industries, but there are some that have not been monitored yet, or where these incidents have not occurred. Of course, the more we investigate, the more we find." And when leaks are found, it is not always clear who is responsible. This leads to what Ted Zuur, toxic-waste representative for the Sierra Club's Loma Prieta Chapter, calls "the same old story . . . finger-pointing exercises."

While the Toxics Coalition continues to push for more action, state agencies such as the San Francisco Bay Regional Water Quality Control Board appear to have their hands tied. Last year the state budget for toxics control was cut back $1.8 million, and this year the electronics industry, the Toxics Coalition, and Silicon Valley legislators all urged California Gov. George Deukmejian (R) to restore the $6.7 million he had cut from the 1984 state budget. At a meeting of the coalition in a Sunnyvale church this July, activists implored the EPA to assist in the cleanup, but received no promises.

In August, Harry Seradarian, director of toxics and waste management for the EPA's western region, appeared at a meeting of the Toxics Coalition to announce that more than a dozen chemical spills in the area had been recommended for inclusion on the federal government's Superfund cleanup list—but he would not say which of the county's 80 major chemical spills made it onto the tentative list. Like EPA Administrator William Ruckelshaus, when he spoke to coalition leader Ted Smith in July, Seradarian told the group that his hands were tied in the matter. The *San Francisco Chronicle* reported Seradarian as saying, "We don't understand the full extent of the contamination. . . . I can't agree to magically clean up these sites. It takes time."

Meanwhile, the Toxics Coalition had joined with other organizations, including the Sierra Club, to push through the state legislature a secondary-containment bill, weaker than the local ordinance, introduced by Assemblyman Byron Sher (D-Palo Alto). Assembly Bill 1362, which became effective January 1, 1984, does not require existing tanks to be upgraded for secondary containment. It requires plants storing toxic materials to obtain permits, to monitor tanks for leaks, to report leaks to local authorities within 24 hours of discovery, and to allow inspection of tanks. The draft legislation required companies to upgrade existing tanks, but that provision was dropped in the face of opposition from the electronics and petroleum industries. Although the high-tech industry supported the local ordinance it helped to create, neither it nor the petroleum industry supported A.B. 1362.

Yet there are some who, citing the record of cleanups for other toxic spills around the country, consider the electronics industry far more cooperative than the petroleum or chemical industries. Silicon Valley industrial leaders, they argue—more sophisticated than administrators of other industries, or even their counterparts elsewhere in the country—seem to have accepted early in the game the inevitability of regulation.

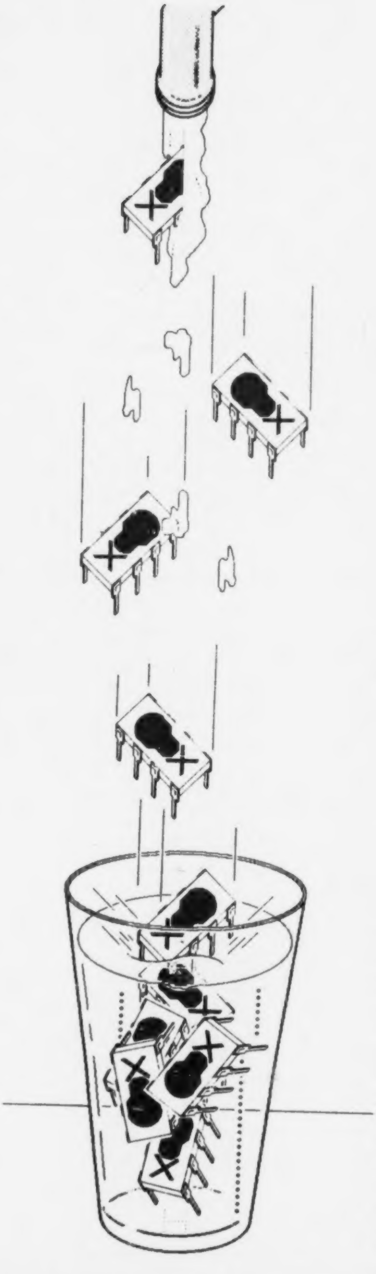
Larry Borgman of Intel, a high-tech firm in Silicon Valley, notes that electronics firms are known for their "fast-moving, problem-solving" mentality. He says, "I think the proper question to ask is why others have not moved to solve their problems." Peter Burnes, waste inspector for the Palo Alto Regional Water Quality Control Plant, answers the question a little differently. "The population here is more sensitive than in other areas. Industry has to respond."

Burnes may have a point. One of the interesting features of the Toxics Coalition's push for regulation is the collaboration of labor and environmentalists in Silicon Valley, two groups that are often seen as having opposing interests. "It's happening all over," says Martin Manley, political director of the Santa Clara Central Labor Council. "It's not as unlikely an alliance as people think. The same chemicals that are polluting the public's drinking water are affecting workers on the job. So if you take that part of labor concerned with toxics on the job, and environmental groups concerned with toxics in the community, and if you define your goals clearly enough, I think you can get a lot of people to work together."

Labor is a significant constituency in Santa Clara County—according to Manley, the valley counts 100,000 union members among its population—and labor has been active in the community for a long time. Workers in electronics, who are underrepresented in an industry Manley says is "famous worldwide for being vehemently anti-labor," are supported by other unions in the Central Labor Council. "I believe we're strong enough to make a difference here," Manley asserts.

Labor found partners among Bay Area environmental groups, and environmentalists in turn found a forum in the Toxics Coalition. "It's true that enviro people and labor don't usually sleep together," says Ted Zuur, "but in toxics they realize they have a common problem, so they have been combining their strength. Ted Smith has welded the groups in the Toxics Coalition together into a formidable organization." Groups such as the "watchdog" Citizens for a Better Environment (CBE), Friends of the Earth, and the Sierra Club's large and influential Loma Prieta Chapter joined with labor to instruct people about the dangers of toxic chemicals and to bring the issue to the attention of residents, local government, and the media.

Yet despite widespread coverage of electronics pollution in the San Francisco Bay Area press, the news of Silicon Valley's problems has hardly leaked outside. As officials throughout North America tout their communities as "Silicon Mountain," "Silicon Beach," or "Silicon Valley East," few living in the nation's many would-be "sil-



icon" regions have heard about the hazards of high-technology production.

The Toxics Coalition hopes to change that situation. "We want to put out the word," says Manley. "Silicon Valley is going and telling the whole planet about how electronics is the industry of the future; well, we want to debunk the myth that it's a clean industry."

Therein may lie the explanation for the industry's relatively compliant attitude. High-tech firms may need chemicals, but they need people even more. Competition for the country's top engineers, scientists, and programmers is high, and Silicon Valley has become a center for high-technology because it has always offered a quality of life that attracts these specialists from throughout the country and the world. According to Peter Giles, president of the Santa Clara County Manufacturing Group, "The perceived and real attractiveness of the area is important to industry as a means to attract and retain people." But how can a high-tech firm lure a young electrical engineer from St. Louis or New York if his or her children have to drink poisoned water in Silicon Valley, once called the "Valley of Heart's Delight"?

Furthermore, the problems of high-tech pollution do not end with leaking underground storage tanks. The electronics industry faces many other, less publicized problems, including waste disposal. In December 1983, CBE's San Francisco office released a report revealing widespread violations throughout the Bay Area of standards for pretreating sewage, noting in particular that one quarter of the 543 industries discharging waste in Silicon Valley were cited for violations in 1982. The city of San Jose withdrew five sewage permits in February and gave four warnings, while the EPA in July ordered 32 Silicon Valley firms, primarily makers of printed circuits, to conform to pretreatment standards immediately or face fines of up to $10,000 per day.

Although electronics companies recycle some toxic solvents, most solid hazardous wastes are transported to landfills 60 to 200 miles away. Not surprisingly, there have been several incidences of improper transfer and disposal of these wastes, including a tank-truck leak in September 1981 that forced 4,000 residents and schoolchildren to evacuate San Ramon, northeast of the Santa Clara Valley.

Finally, air pollution, though not attributable primarily to high-tech firms in the Bay Area, is another waste product associated with the electronics industry. The Bay Area Air Quality Management District estimates that semiconductor firms in the Silicon Valley produce ten tons per day of "ozone precursors," or smog-producing emissions. Eight large firms produce 74 percent of that total.

So, despite the industry's responsiveness (relative to other industries), the Toxics Coalition is not appeased. Ted Smith says, "They have poisoned our water. They've polluted our air. They consistently try to weaken or delay regulation. That hardly makes them responsive."

Martin Manley agrees. "It's true that there's a difference in attitude between the electronics and oil industries where regulation and compliance are concerned—oil is far worse. But it's electronics that's causing all the grief around here. Silicon Valley is not unique in the country for a superabundance of gas stations; but we are unique in the density of the electronics industry: It's the largest high-tech center in the world."

And in the San Francisco Bay Area, at least, there is growing evidence that the public is beginning to think twice about letting electronics firms into its hometowns and backyards. In Sonoma County, north of San Francisco, community organizations have opposed all high-tech growth, citing both the threat of pollution and Silicon Valley-style congestion as reasons to reject the industry. In early 1984 a Mountain View producer of printed-circuit boards announced that it planned to shut down its plant, which employed more than 400 people, because the firm could not comply with the community's orders regarding sewage cleanup or its secondary-containment ordinance. No one protested. However, when CTS Printex announced that it was moving its plant across the bay to Fremont, residents there quickly organized Sensible Citizens Reacting Against Hazardous Materials (SCRAM) to block the proposed move.

Concerned citizens in most locales around the country, however, seem to feel that the electronics industry should be accepted, but under conditions that would help ensure its responsible behavior. This means that comprehensive regulations, including the funds to enforce them, would have to be in place before companies "grandfather in" ineffective methods of handling hazardous materials. In addition, electronics production must be kept a safe distance from residential neighborhoods and environmentally sensitive natural resources, such as vulnerable sections of underground water supplies. And because most planners recognize the need for suitable housing within a short commute of industrial areas, it all calls for careful planning.

But in the long run, the record of leaks, spills, dumping, and venting in Silicon Valley demonstrates that without assertive public agencies—backed by the combined effort of well-informed community organizations—the electronics industry cannot be counted upon to make public health and safety a high priority. Martin Manley notes that the experiences of Silicon Valley ought to serve as "a warning to everybody that you shouldn't assume high-tech is a panacea for the problems in your community. You have to do some planning, look at the consequences, look at the needs of the community, and work from there." ◻

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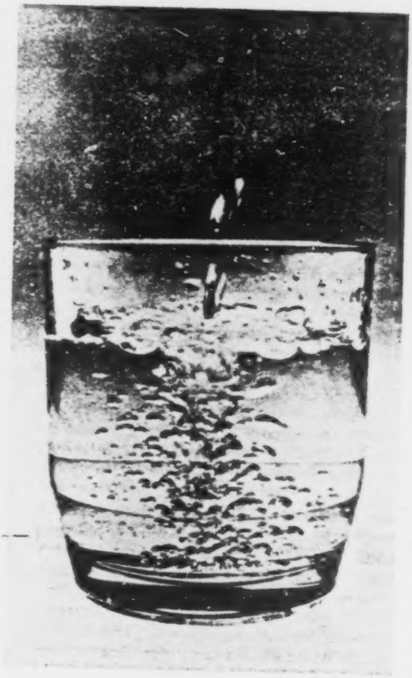
IV. RESOLVED: THAT THE FEDERAL GOVERNMENT SHUOULD ESTABLISH A NATIONAL POLICY TO INSURE EACH UNITED STATES RESIDENT AN ADEQUATE SUPPLY OF POTABLE WATER FOR PERSONAL USE

Water, Water Everywhere

Jacqueline M. Warren



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But is it safe to drink? Faced with the great expense of cleaning up wells contaminated by organic chemicals, communities in California, Connecticut, Massachusetts, Michigan, New Jersey, New York, Tennessee and Wisconsin have been forced to close their wells and seek other sources.

For half a century it has been said that America has the safest drinking water in the world, but today the facts suggest otherwise. Drinking water supplies throughout the United States have been widely contaminated with industrial chemicals.

Claims about the safety of drinking water stem from the virtual eradication in this country of communicable water-borne disease. However, organic chemicals pose a new and different threat. An objective assessment of the situation reveals a drastic inadequacy in the response of U.S. water supply officials to widespread chemical water pollution resulting from the mushrooming chemical and petrochemical industry of the past three decades.

SURFACE WATER. Surface water supplies in the United States are contaminated by more than 700 organic industrial chemicals, heavy metals, pesticides, and other pollutants including vinyl chloride, carbon tetrachloride, dieldrin, trichloroethylene, tetrachloroethylene, chloroform, kepone, PCBs, and benzene. Twenty-two of these chemicals have been identified by the National Academy of Sciences as carcinogens and many others as mutagenic or otherwise toxic. The vast majority have not even been tested for potential toxicity. Moreover, it is estimated that the 700 chemicals represent only a small fraction, perhaps as little as 10 per-

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cent by weight, of all the organic chemicals present in drinking water.

Chemical contamination of surface drinking water supplies comes from widespread, multiple sources—industrial discharges, spills and accidents, urban and agricultural runoff, municipal sewage effluents, and chlorination of drinking water and sewage for purposes of disinfection. While untreated surface water is not generally considered pristine water for drinking, the public is not well aware of the fact that drinking water treatment in the United States is limited almost exclusively to disinfection. Usually done by chlorination, drinking water treatment was originally designed to prevent outbreaks of diseases such as cholera and typhoid. Consequently, the overwhelming majority of treatment plants neither remove nor detect the presence of organic chemicals. With very few exceptions, surface water supplies remain completely vulnerable to serious chemical contamination.

GROUNDWATER. Groundwater (subsurface water occurring in permeable geologic formations called aquifers) is the primary source of drinking water for 50 percent of the U.S. population. The conventional wis-

NEW YORK WON'T WAIT

HESITATION AT THE FEDERAL LEVEL has prompted at least one state, New York, to contemplate adopting its own program for alleviating toxic contamination of drinking water. The presence of toxics in aquifers in Long Island, where groundwater is the sole source of supply, and in other parts of the state has been known for several years. Intense local controversies have often followed identification of contaminants such as trichloroethylene and other solvents, PCBs and aldicarb, a potato pesticide. In Glen Cove, Long Island, five of nine wells were closed as a result of tri- and tetrachloroethylene contamination, requiring water purchases from adjacent communities. In Poughkeepsie, which takes its water from the PCB-contaminated Hudson River and has no practical alternate source of supply, conflict has arisen between consumer groups, the City and the State Health Department over the level of health risk to which residents are exposed. Only a few water supplies across the state have been tested for a broad range of possible toxic contaminants, but in most cases some level of unwanted chemicals has been found, usually plastic compounds, solvents or petroleum products.

State Health Commissioner David Axelrod, a longtime advocate of tighter controls on toxics, is considering recommendations to move ahead with a program of identifying and dealing with synthetic organic chemicals. He has already ordered all water supplies in the state to be tested for a broad band of toxics, a process which will take many years at present rates of testing. A report he has received from Langdon Marsh, a former deputy commissioner of the state's Department of Environmental Conservation, recommends that the state not wait for the federal Environmental Protection Agency to establish maximum contaminant levels for the chemicals which are frequently found in New York. Marsh points out that even prior to the change of administration in Washington, EPA had no schedule for adopting standards for chemicals other than six that are found almost nationwide. New York has already found other chemicals in drinking water which are known to be carcinogenic, mutagenic or otherwise harmful to health. In addition to tight standards, the report recommends a broad range of preventive, monitoring and public education actions. Commissioner Axelrod is now considering these recommendations and has been quoted as saying that standards would be issued within a year. "New York traditionally has been in the forefront of assuring public health and the state is continuing to do so," Axelrod said.

The most controversial recommendation in the report is that the level of risk to be used for establishing an appropriate drinking water standard for a particular chemical be one which will result in only dom is that groundwater, in contrast to surface water, provides a protected source of drinking water, because the ground acts as a natural filter for the removal of impurities. Recent studies have shown, however, that much groundwater is highly contaminated by toxic industrial solvents such as trichloroethylene and tetrachloroethylene and often at much higher levels than those found in drinking water taken from the most polluted surface supplies. For example, the largest concentration of trichloroethylene ever recorded in surface water is 160 *parts per billion* (ppb). By contrast, the President's Council on Environmental Quality recently reported that a level of 27,300 ppb was recently measured in a well in Pennsylvania.

Every day newspapers report another discovery that well water has been rendered unfit for drinking because of improper hazardous waste disposal or industrial activity in an aquifer recharge area. Such widely reported problems have led to the closing of public and private wells in Maine, Massachusetts, Connecticut, New York, New Jersey, Tennessee, Michigan, Wisconsin, and California. There is now serious concern at all levels of government about the long-term viability of our groundwater resources as a drinking water supply.

The sources of organic chemicals in groundwater are numerous. They include disposal of hazardous wastes in landfills and industrial surface impoundments (pits, settling ponds, and lagoons); septic tanks and cesspools and the chemicals used to clean them; municipal waste water; mining activity; petroleum exploration and development; and agricultural, street, and urban runoff. Because groundwater lacks the self-cleansing properties provided surface water by dilution, circulation, and degradation by sunlight and aquatic organisms, groundwater can remain contaminated for centuries.

Although groundwater itself moves slowly, often only 10 or 20 feet a year, the contaminants move in unpredictable *plumes,* the behavior and flow rate of which are difficult and costly to measure. Moreover, once the contamination is detected, few remedies are available, and these are often economically or technically unfeasible.

The best alternative to a contaminated well is a new well. Clean-up involves pumping out, treating vast amounts of the well water, and then returning it to the ground. Other alternatives are bottled water and home water filter devices, but both are expensive and of

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one-in-one-million chance of dying from cancer in a lifetime of exposure. While of no solace to the individual who happens to be one in a million, the risk level is considered very low by most scientists and government regulators. EPA used a much higher level for setting limits on concentrations of trihalomethanes (THM's) in finished drinking water. The science or art of risk assessment has been much debated and has significant technical and conceptual flaws, but at the moment is considered the best available starting point for establishing acceptable levels of exposure.

The report recognizes that use of a low risk level to set standards may have severe economic consequences to particular water suppliers. According to the report, cost factors should not be used to weaken standards through some kind of mechanistic cost-benefit analysis, which usually results in underestimating difficult-to-quantify health benefits. Tough standards should be applied to all water suppliers with an opportunity for weighing the risks involved in setting the standard against the costs involved in compliance for a particular water supplier. Depending on such factors as the level of contaminants found, the potential adverse health effects, the duration of exposure of affected populations and the degree of certainty of scientific evidence, compliance with the standard could be stretched out over time while new supplies are sought, treatment systems explored and financing arranged. Monitoring of levels of contaminants would be required of any supplier under an extended compliance schedule.

One of the advantages of providing an extension mechanism to deal with severe economic impacts is that it should take the focus of litigation away from the scientific evidence underlying the standards themselves. In a case decided by the the U.S. Supreme Court in 1980, an OSHA standard on airborne benzene was overturned because the health data underlying it was found insufficient by a plurality of the justices. That meant that the standard was unenforceable everywhere, even where compliance would not have been particularly burdensome. Changing the focus of legal challenge to the denial of a time extension should concentrate the courts' attention on the regulators' action in a concrete case. Even if the health department's judgment were overturned in that case, the standard would remain applicable to everyone else.

New York's approach to the bedeviling problem of dealing with the risks of synthetic organic contamination in drinking water bears watching as a possible precedent for action in other states. It ultimately may be followed at the federal level when interest in regulating organics reawakens at EPA.

questionable efficacy. Bottled water is subject only to sporadic surveillance by the Food and Drug Administration, and by law need only meet existing EPA drinking water standards which do not consider the vast majority of organic chemicals that have been found in drinking water. Consequently, bottled water may in fact exceed the chemical quality of tap water. Home filter devices, with a few exceptions, have been shown in recent studies by the Environmental Protection Agency to be inefficient generally in removing organic chemicals. Moreover, unless an individual homeowner can have the water routinely sampled and analyzed to ensure that the device is maintaining its removal efficiency, the investment, which can amount to several hundred dollars, is not worthwhile. Nevertheless, consumers are spending $400 to $500 million a year for bottled water or home water filters.

Faced with the great expense of cleaning up contaminated wells, many communities have been forced to close their wells and seek other sources of supply. For example, 39 public wells were closed in the San Gabriel Valley, California, in January 1980. Although the wells supplied water to 400,000 people in 12 cities, California public health officials ordered them closed, because of high levels of trichloroethylene, an industrial solvent found to be carcinogenic in experimental animals. Similar contamination and well closings have occurred in New York (especially on Long Island), New Jersey, Pennsylvania, Connecticut, Massachusetts, and Maine. In every case, the contaminants were organic chemicals in high levels, many known to cause, or suspected of causing, cancer or genetic mutations. Among the chemicals most often found in high concentrations in wells are trichloroethylene, 1,1,1-trichloroethane, tetrachloroethylene, carbon tetrachloride 1,2-dichloroethane and vinyl chloride. The similarities in patterns of contamination suggest that the problem is widespread.

Careful siting of residential development, road construction, industrial activity and waste disposal facilities is critical to the prevention of groundwater contamination.

To illustrate the potential magnitude of only one aspect of the problem, a recent survey of 176,647 industrial waste impoundments conducted by the federal Environmental Protection Agency showed that 95 percent of the sites were not being monitored for groundwater contamination and that 70 percent of the impoundments were unlined. Thirty percent of the unlined industrial impoundments were found to "overlie usable aquifers and are underlain by unsaturated zones which freely allow downward movement of any liquid wastes escaping from the impoundment." Thus, both the extent and the number of groundwater contamination incidents can be expected to increase in the foreseeable future.

THE SAFE DRINKING WATER ACT. Drinking water has traditionally been a matter of state and local jurisdiction. In the late 1960s and early 1970s, however, various agencies of the federal government began to be concerned about the extensive presence of organic chemicals in drinking water supplies throughout

the country, and the apparent inability or unwillingness of state and local authorities to address the problem. Congress responded in 1974 by enacting the Safe Drinking Water Act, authorizing the Environmental Protection Agency to establish uniform national standards for drinking water.

Further impetus for a federal drinking water law had been provided by studies of public water supply systems showing great variations among states in the quality of drinking water and of water treatment practices. As set forth in the House Report on the Safe Drinking Water Act, 56 percent of the 969 systems studied showed physical deficiencies in the protection of groundwater sources and in disinfection capacity; 77 percent of the plant operators were inadequately trained, and most systems were unprotected against contamination from sewage cross-connections; 79 percent of the systems were not inspected annually by state or county authorities; and 69 percent did not even analyze for half of the contaminants listed in 1962 by the U.S. Public Health Service in drinking water standards for interstate carriers. In addition, surveillance of drinking water quality was so poor that 90 percent of the systems covered by EPA's Community Water Supply Study "had no idea what the chemical quality of their drinking water was." Other widespread problems noted in the House report were the lack of adequate, inexpensive monitoring or measurement methods; the proliferation of small water systems which do not support well trained full-time operators and necessary equipment; inadequate health effects research; and the increasing demand for drinking water at a time of increasing pressure to dispose of contaminants in ways that may endanger drinking water quality.

The Safe Drinking Water Act established a regulatory framework within which the Environmental Protection Agency sets drinking water standards called "maximum contaminant levels" or prescribes water treatment techniques which are uniformly applicable to community water systems across the county. The EPA is also authorized to establish minimum national requirements to ensure that underground injection of wastes does not endanger groundwater supplies used for drinking. And, lastly, the agency may designate certain groundwater sources as "sole source aquifers," i.e., providing the sole source of drinking water for a given area, and may then withhold federal financial support from contaminating activities in the area. As with other environmental statutes such as the Clean Air Act and the Clean Water Act, primary enforcement responsibility is delegated to the states, once their state programs are approved by EPA. But unlike the Clean Air Act and the Clean Water Act, the Safe Drinking Water Act gives EPA neither the necessary grant money nor sanctions to provide incentives for the development and enforcement of strong programs by the states.

The absence of significant federal financial assistance or compliance initiatives has left its mark on the federal drinking water program. Despite clear signals from Congress that organic chemicals were high on the list of contaminants to be addressed under the Safe Drinking Water Act, EPA has made only slow and piecemeal efforts to deal with this problem. The first set of drinking water standards issued by EPA in 1975 did not include organics, except for a handful of pesticides and herbicides contained in the old 1962 Public Health Service standards. The many carcinogenic chemicals and other toxic substances known to be widespread in surface water supplies were not included.

Following a lawsuit by the Environmental Defense Fund in 1975 and a change in administrations, EPA in 1978 proposed a comprehensive regulation to reduce the level of organic chemicals in drinking water. First, the agency proposed a maximum contaminant level of 100 *ppb* for trihalomethanes—chemicals produced in water treatment plants by the chlorination process. Trihalomethanes include the carcinogens chloroform and bromoform, as well as bromodichloromethane and dibromochloromethane. Of these, chloroform has been found in every sampled system that chlorinates for disinfection, and detection of the other trihalomethanes has been almost as common.

The second aspect of EPA's organics proposal was a requirement that water supplies drawn from a source contaminated to a certain degree by synthetic organic

From *Water Quality in a Stressed Environment*. Burgess Publishing Company, 1972.

How leachate from a landfill can contaminate groundwater aquifers with toxic substances.

chemcials install removal technology such as granular activated carbon filters. Activated carbon has been used successfully in the water treatment, waste treatment, air treatment, food processing, beverage manufacturing, and sugar refining industries. Currently, more than 60 water treatment plants in the United States use activated carbon for taste and odor control, as do more than 20 municipalities in Europe for the control of trace organic chemicals of health significance.

The organized water supply industry in the United States, led by the American Water Works Association and an *ad hoc* group of water utilities calling itself the Coalition for Safe Drinking Water, objected strenuously to EPA's proposal to control organics in drinking water. Viewing the proposal as unnecessary, an insult to their professional pride, and unduly expensive, they challenged the preventive health rationale for the proposed requirements, as well as the safety and efficacy of available removal technologies. By persistent and strident opposition the water suppliers succeeded in persuading EPA to withdraw the treatment technique proposal. The agency promulgated the 100 *ppb* trihalomethane standard, however, and is currently defending its action against a challenge brought by the American Water Works Association in the U.S. Court of Appeals for the D.C. Circuit. The water utilities also took their objections to Congress, where a serious effort to weaken the Safe Drinking Water Act was narrowly defeated in the last session of Congress.

. . . "cradle-to-grave" hazardous waste management programs that most states are developing . . . should help to prevent future drinking water contamination problems by controlling the disposal of toxic wastes.

At the same time that EPA, the water utilities and environmentalists were engaged in skirmishes over the proposal to address the problem of organic contaminants in drinking water, evidence was accumulating that the problem extended far beyond surface water sources. Neither of the approaches to organics control contained in the EPA proposal (numerical standards or treatment techniques) is appropriate for groundwater. Under the Safe Drinking Water Act, monitoring is only required after standards are promulgated, and remedial action is taken only after those standards have been exceeded. Similarly, treatment techniques only need be applied after a problem has been detected. Once concentrations of toxic chemicals in groundwater exceed standards, however, the damage is done and remedial action is unlikely to be available or affordable.

Groundwater protection requires an entirely different approach. Groundwater contamination must be prevented by controlling polluting activities in sensitive aquifer recharge areas. Careful siting of residential development, road construction, industrial activity and waste disposal facilities is critical to the prevention of groundwater contamination. To this end, EPA is in the process of devising and circulating for comment a comprehensive groundwater protection strategy to be recommended for adoption by the states.

Implementation of such a strategy through zoning, restrictions on underground injection of wastes, and regulation of hazardous waste disposal will provide some protection for vulnerable groundwater supplies. However, the damage from existing landfills, impoundments, abandoned hazardous waste sites and similar contamination sources cannot be easily remedied. Recently enacted legislation to create a federal "superfund" to clean up such sites should be helpful in minimizing the damage from future Love Canals, but only a long-term commitment by states and local communities to maintain the integrity of our remaining unsullied groundwater resources will be able to prevent future groundwater contamination.

Even if such a commitment were made, our knowledge of the existing state of groundwater quality is deficient. We must evaluate the quality of groundwater supplies, learn where the critical aquifer recharge areas are located, and determine how groundwater resources are to be utilized in the future. It is a massive undertaking, and the ongoing activities and exigencies of modern industrial society are likely to conflict directly and often with requirements for groundwater protection.

Drinking water has been a neglected resource for many years. Now that the severity of the problem is becoming increasingly apparent, efforts are underway to clean up polluted sources and to prevent future degradation of both ground and surface waters. Despite the enormity of the task and the many competing demands on our resources and attention, there is some basis for cautious optimism. First, the comprehensive EPA program to control industrial discharges of toxic pollutants into water, obtained by the Natural Resources Defense Council in settlement of a series of lawsuits in 1976, is due to be completed by 1984 for the 21 major industrial categories affected. This program will significantly reduce the quantity of toxic pollutants currently discharged into the nation's waterways and therefore lessen the concentrations of organic chemicals and other toxic substances in surface drinking water supplies.

Second, "cradle-to-grave" hazardous waste management programs that most states are developing under the Resource Conservation and Recovery Act should help to prevent future drinking water contamination problems by controlling the disposal of toxic wastes. Such programs are expensive to administer, however, and the projected reduction of federal financial assistance to the states may drastically curtail the implementation of effective hazardous waste management programs. The potential impact of the cut in federal aid could be dramatic. New York State, which has been developing a state hazardous waste management program widely acclaimed as "bold" and "forward-looking," presently depends upon the federal government to meet 80 percent of the costs of its present hazardous waste management efforts. The new program is estimated to cost four times as much while the percentage of federal aid is expected to decrease markedly.

The strongest basis for optimism is the public's growing awareness of the problem of the risks posed by exposure to hazardous substances in drinking water, and of the reasons why their water supplies have become tainted or even unusable. The demand for action to remedy existing problems has prompted Congress to enact a major new federal spending program, "superfund," at a time when most other federal programs were being cut back. The change in administration is unlikely to lessen the outcry unless some constructive actions are taken to assure the public that their water supplies are again safe to drink. □

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The good, the bad and the ugly

The search for safe drinking water in America

Richard Asinof

When Frank, a middle-aged businessman from northern New Jersey, was courting Mary, a garment industry consultant from Queens, N.Y., Frank would bring empty plastic jugs to fill up with New York City water when he picked her up on Friday evenings. Anything was better than what came out the faucets at Frank's suburban New Jersey home. Besides, he says, New York City has some of the best drinking water in the country—according to *Consumer Reports.*"

In New Orleans, where the drinking water comes from the Mississippi River, many people go to great lengths to avoid drinking any tap water. Forty percent of the continental United States drains into the Mississippi, and by the time it reaches New Orleans the river water carries with it hundreds of contaminants. In this delta city it's common for salesmen to go door to door hawking bottled water.

"Philadelphia water? I didn't know water could taste so terrible," says an energy lobbyist from Washington, D.C., recalling visiting her grandparents in Philadelphia when she was a child. While many people would agree that Philadelphia water, which is drawn from the Schuylkill and Delaware Rivers, still tastes terrible, it meets all health and safety standards. In fact, Philadelphia is one of the leaders in experimenting with carbon filtration systems to eliminate toxic contamination. "We produce a water that is very safe," says Thomas E. Walton, deputy water commissioner for the city of Philadelphia. "We wish that it tasted better."

There's a whale of a difference, as Charlie the Tuna found out, between good taste and what tastes good. And in drinking water, what tastes good may not be safe to drink, while what tastes awful and looks disgusting may actually be healthy.

More and more, as the quality of drinking water deteriorates—and as the number of dangerous contaminants increases—people want to know what's really in their drinking water. What they discover is an appalling lack of standards.

On a national level, drinking water is regulated by the Environmental Protection Agency (EPA) under the Safe Drinking Water Act of 1974, which sets standards for turbidity (the amount of solid particles in the water), coliform bacteria and inorganic chemicals such as lead, mercury, arsenic and cadmium. It also sets maximum contaminant levels (MCLs) for six organic or carbon compounds—endrin, lindane, methoxychlor, toxaphene, silvex and 2,4-D—and for four trihalomethanes—dangerous compounds formed when the chlorine used in treating water combines with chemicals already in the water. But more than a hundred unregulated organic chemical contaminants have already been found in our nation's drinking water.

Some states, such as New York and New Jersey, have adopted drinking water standards more stringent than the federal ones. In New York, no single synthetic or man-made organic substance may exceed 50 parts per billion, and the total of all organic substances may not exceed 100 parts per billion. In addition, contaminant levels have been set for such dangerous substances as vinyl chloride, aldicarb, benzene, PCB and TCE. Most states, though, are content to meet the minimal federal standards.

Establishing standards is one thing; compliance is another. In 51 out of 57 states and territories, supervision of testing for these contaminants is left up to the state government. In most cases, the water company itself does the testing and is responsible for reporting any violation to the state, which then passes that information on to the EPA.

The quality of results is often directly parallel to the technical expertise of the laboratories. When New York City recently upgraded its technical facilities for testing water, for instance, it discovered 16 toxic chemicals that had gone undetected at the Jamaica Water Co. in Queens, which serves 520,000 city residents.

How then, does one rate the quality of drinking water? By its taste? By its comparative mineral content? Is it by epidemiological studies that attempt to correlate incidences of rectal and bladder cancer with toxic pollution?

The sanitary quality of drinking water at the turn of the century, for instance, was often measured by the number of typhoid fever cases. Although water-related diseases still plague many Third World countries, typhoid and other infectious diseases have virtually been eradicated from public water supplies in America.

"It doesn't do anybody any good to rate the best and worst drinking water," says Joseph Cotruvo, director of the criteria and standards division of the Office of Drinking Water at EPA. "It would just make people unhappy. Obviously, there are some drinking water supplies that are not pristine. . . . It's not a black and white issue. As the Supreme Court Justice—I think it was Potter Stewart—said when they were arguing about pornography, 'I know it when I see it.' "

Obviously, Cotruvo doesn't live in New Orleans, where the issue of safe drinking water is as hot as the Louisiana summer. According to studies conducted by the EPA, the state of Louisiana and even the local New Orleans newspaper, *The Times Picayune*, anywhere from 73 to almost 200 synthetic organics, heavy metals, pesticides and suspected carcinogens have been found in the water. White males in south Louisiana reportedly have one of the highest bladder cancer mortality rates in the country. And according to Dr. Marise Gottlieb, an epidemiologist with the Louisiana State Health Department, people who drink from the Mississippi have a much higher rectal cancer rate than those who drink from underground aquifers.

Vernon "Buck" Parker with the Louisiana division of health and human resources drinks as much as he can of Mississippi River water. "I love it; I'm not concerned at all about it. I don't hesitate to drink it, nor to have my family drink it." The only thing the studies have shown, he says, is the need for more study. "The real problem," he continues, "are the unknown, the less popular chemicals, the ones that aren't buzzwords like dioxin—some of these compounds that look like 35 or 40 letters and take five minutes to pro-

The people's choice

In March we asked our readers for suggestions and nominations for the best and worst drinking water in the United States. We received a large number of replies, and although we can't list all of them, here is a sampling of opinions.

The Good

"One of the best clean water sources in New York State if not the whole country is Lake Skaneateles in upstate New York . . ."
—Rich Fedele, Auburn, N.Y.

"The very cleanest, sweetest most delicious water I have ever tasted in the world is found in the Catskill Mountains of New York State in a little town called Halcott Center . . ."
—Peggy Di Benedetto, Roxbury, N.Y.

"I have always been impressed with the palatability of the drinking water here in Dallas, even to the point of once writing to the Dallas Water Utilities and congratulating them about it . . ."
—Phil Mendershausen, Dallas, Tex.

"My good palatability and clarity award would go to State College, Pa. I'd describe that water as sweet . . ."

The Bad

"Bad water? You bet. Amarillo and Lubbock, Texas and any other towns that drink water from the Canadian River in the Texas Panhandle . . ."
—Robert Baumgardner, Jr., Austin, Tex.

"I am writing to nominate Asheville, N.C. As you probably know, the EPA refused to permit Asheville water to be used aboard interstate planes, trains or buses . . ."
—The Satterfields, Enka, N.C.

The Ugly

"My nominee for the worst water would be the city of Philadelphia, but then I never tried the water near Love Canal, which undoubtedly has memorable characteristics. Also notable was the chemical taste and abundant chlorine of Rochester, N.Y. water. (Thanks, Kodak?)
—Kate Keim, Lewiston, Penn.

"The worst drinking water in the U.S. is in Hanford, Calif. The water has a high concentration of sulfur and smells like rotten eggs!"
—Linda Johnson, Palo Alto, Calif.

"The worst drinking water is in Santa Monica, Calif.; the water tastes like it comes from a swimming pool . . ."

"The most disgusting water I have ever tasted was in southwestern Florida in Everglades City. Running a close second is the water supply found in Huntsville, Tex. . . ."

"The worst drinking water? It's gotta be from our northwest area of Dade County . . ."
—Harry "Dump Watt" Rothwell
Sierra Club, Miami, Fla.

nounce. We don't know what the adverse health effects are to being exposed to these in tiny amounts."

Maureen O'Neill, administrator with the Sewer and Water Board of New Orleans, also drinks Mississippi River water, but she is much more skeptical about its contents. And she doesn't see bottled water as a panacea. "It's delusion to think that bottled water is any better," she says. "Unless you know that it's been tested, you have no assurance as to what is really in the water. People think that being in a bottle makes it magic. Bottled water is regulated by the Food and Drug Administration as a food; it doesn't have to be tested very often. It might be the purest stuff in the whole world, but it's possible that it could be contaminated," she cautions.

O'Neill is adamant about the need for stronger national standards, and angrily denounces the budget cuts in the research programs at the EPA. "A lot of national attention has been focused on New Orleans and its drinking water. We at least have an idea of what's in our drinking water. And our testing program and laboratories are excellent. Many other places don't have any idea what's really in their water. It's imperative that strong national standards be set."

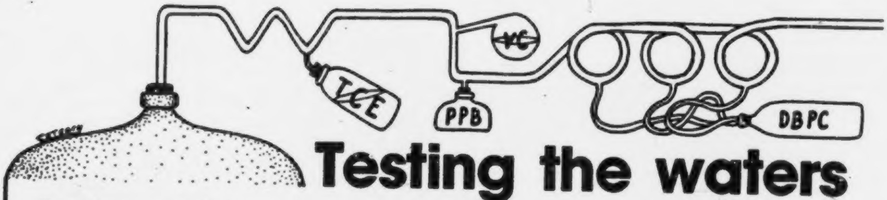
For Dr. David Axelrod, New York State's Commissioner of Health, providing safe drinking water is inherently a political decision. Setting standards by determining significant risk, Axelrod told an audience of health professionals gathered at an April symposium on Drinking Water and Human Health jointly sponsored by the American Medical Association and EPA, is not just a scientific equation. "When you talk about significant risk," he said, "you're making a political determination that there is a level at which risk is no longer significant. Setting the risk level at one death in a million over a lifetime of use [as New York State does] is a political judgment."

The conference, the first of its kind, was an attempt to bring together both regulators and health professionals to address the problems of illness related to drinking water. "Drinking water contamination is a long term problem for physicians and medical providers," Axelrod says, "and the AMA joint sponsorship is indicative of an increasing recognition that physicians need to know more and should play a greater role."

The only way to really protect water, Axelrod argues, is to control contamination at the source by strictly enforcing regulations or by making pollution too costly for an industry. "Removing it at a later date is so much more expensive," he says.

"Nobody knows the *synergistic* effect of a zillion chemicals in the water," says Nancy Wentworth, director of the EPA's state water management program. If one contaminant is toxic in a certain concentration, how does it interact with other toxic compounds and what are the health consequences? That's only one of many unanswered questions about safe drinking water that underscores the need for more research. Yet on both the state and federal level, research funds are often the first items cut in budget crunches.

Until the federal government makes the development of stringent national safe drinking water standards a major priority, the answers will be slow in coming. As Axelrod comments, it is a question not of science, but of politics and public policy: at what level are people willing to tolerate the chances of developing disease and cancer from public drinking water supplies? And what are they willing to pay to prevent it?



Testing the waters

Remember the good old days—when the first question you asked someone selling a home was "What are the neighbors like?" instead of "How safe is the water?"

People are worried about the purity of their drinking water—and for good reason. Half the U.S. population drinks, cooks and bathes with groundwater that comes from unmonitored private wells. Most of these private wells are likely to contain at least one pollutant in concentrations that some health scientists believe may cause chronic illness in adults and children. Unfortunately, there are rarely any clues that your well is contaminated. A glass of water from a tainted well usually looks, smells and tastes quite harmless. So, what can concerned citizens do to find out how safe their well water is?

The logical step is a water test. Most county and state health departments will test for pH, alkalinity, hardness, iron and bacteria levels. Analyses for turbidity (the amount of sediment in the water), taste, color and odor can usually be obtained, free of charge, from private companies that supply water softening equipment.

But if you're worried that heavy metals or organic chemicals may be lurking in your well, getting your water tested for these contaminants will be far more difficult—and expensive—than you imagine.

In New York, for example, some counties want nothing at all to do with testing for organic chemicals, such as dioxin or trichloroethylene, a solvent. Other counties will have your water analyzed only if there is a *proven* health hazard or if you obtain a signed statement from your physician. The letter should explain that your family has a history of illness, which the doctor believes might be caused by contaminated water. Most counties blame staff and funding cuts for their limited services.

In Illinois, most county health departments will test for nitrates, which come from fertilizers and animal wastes, but not organics. Again, citizens are referred to a laboratory for organics analysis. One Illinois lab, for example, said that tests for organics are only done when there is an evident public danger such as a chemical spill. The laboratory representative, who insisted on remaining nameless, stressed they are doing the best they can under the restraints of reduced budgets and manpower. Because of federal funding cutbacks, one Illinois EPA lab can now only offer routine water tests.

If you contact a health department for a water test "just in case" your well is polluted, you're unlikely to get results. The best approach is to raise reasons why you are concerned certain chemicals may be in your water—for example, you live near a landfill or your children are constantly getting headaches. Explain that you think you might have a problem and ask what the health department would advise.

If you are referred to a private lab, make sure the laboratory primarily performs water analyses and has a graduate chemist in charge. Local facilities probably know which pollutants are most likely to be of concern in your area.

Beware of do-it-yourself field test kits because these cannot accurately

—Michelle Teiman

detect traces of heavy metals and organic chemical pollutants. Highly sensitive equipment such as gas chromatographs and absorption spectrophotometers are a must.

Laboratory testing quickly becomes quite an expensive proposition. Unless you are testing for a specific contaminant, labs will initially run a spectrum test which narrows down the number of probable chemicals in the sample to about twenty. When you consider the fact that there are six million known chemicals, 63,000 of which are regularly used by industry, and that 1,000 new chemicals are developed daily—the potential findings in that one water specimen are astronomical. For more specific results, each chemical must be individually tested for at a cost that typically ranges from $50 to $1,000 *per chemical.* Without financial assistance from government agencies, most people can't afford to run extensive tests on their well water.

Additionally, one sample is hardly enough. Groundwater contamination is often caused by plumes, travelling "clouds" of pollutants, which can be detected only at certain points in time because of groundwater's snail-like movement. A well, certified as clean this summer, could be contaminated by next spring. For an accurate assessment, water needs to be tested several times over an extended time span.

Even if you can afford the cost, you may still have problems getting your water analyzed. Some labs will refuse to test for "controversial" organics, such as known or suspected carcinogens, for fear of being sued.

Local health departments often avoid the issue of water contamination because it raises unanswered questions like: who's responsible, who'll pay, and what it does to the community image.

Health departments may fear that people will opt to live elsewhere if they learn about local water problems. Constantly changing safety standards and inconsistencies between state and federal regulations add to the confusion. As more labs close their doors to private individuals, government action at some level will be needed to insure that this important testing is done.

But a wider testing program isn't the answer without some action by EPA and the states. EPA has failed to establish health standards for most of the toxics that people are likely to find in their well water. Thus, even if you know what's in your water—and how much of it—you won't really know if your health is in danger. Three states—New York, New Jersey and California—are working to set their own standards. Citizens can contact their state health departments to find out where their state stands.

Citizens must make it clear to elected officials that a funded program to test and protect groundwater is necessary—half of our nation depends on it. But even more important, if more people know about the difficulty and expense of testing, more people will demand an end to chemical contamination in the first place.

Michelle Teiman, who is currently completing her masters degree in Resource Economics and Communications Arts at Cornell University, is a freelance writer in upstate New York.

POINT . . . AND COUNTERPOINT

Groundwater Contamination—How Serious is the Problem?

by Dayle E. Williamson,
Nebraska Natural Resources Commission

As we progress into the 1980s and beyond, greater demands are being placed on our groundwater resources. Coupled with the demands are growing concerns about groundwater depletion and pollution.

On a typical day, the United States Geological Survey (USGS) reports that Americans use 450 billion gallons of water from both surface and groundwater sources. About 20 to 25 percent of that total comes from groundwater. Groundwater is a major drinking water source for 32 states. Approximately 80 percent of the municipal systems in this country rely on groundwater for their supplies. These systems serve roughly 30 percent of the U.S. population.

Irrigation is by far the biggest single user of groundwater. USGS estimates for 1980 show 60 billion gallons of groundwater used daily (bgd) for irrigation or about 40 percent of the total water used for that purpose. The amount of groundwater used for irrigation has increased steadily since 1950. The largest increase came between 1970 and 1975—a 27 percent increase. The increase from 1975 to 1980 amounted to 5 percent, a level that could easily continue for years to come.

With the ever-increasing dependence of groundwater, overdraft problems are becoming common in many areas of the country. In some western states, heavy use of groundwater has caused reduced flows

Williamson *Continued on page 28*

Groundwater Pollution and Protection: The Federal Role

by James T.B. Tripp,
Environmental Defense Fund

Our country is rich in natural resources. It is particularly blessed with huge reservoirs of groundwater. These natural reservoirs store large volumes of water for long periods, not affected by annual variations in precipitation to the degree that surface waters are. Yet, groundwater is recharged and is thus a renewable resource. Its proximity, natural storage capability, and low cost associated with its use explain why the utilization of groundwater has increased rapidly in recent years.

These large underground reservoirs of water should therefore be considered as much of a national resource as are our lakes, rivers, streams, and wetlands, which the Clean Water Act declares to be "waters of the United States." Yet, because both pumpage and pollution of groundwater takes place through land, control over both use and contamination of groundwater has been politically viewed as a local or state concern. Only with the gradual recognition in the mid-1970s that toxic chemicals unexpectedly were moving into groundwater and that the earth's soils did not pose a substantial barrier to toxic wastes deposited on or into land did Americans and their Congress, rather indirectly, come to view protection of the quality of the Nation's groundwater as a federal responsibility.

Since passage of the Safe Drinking Water Act in 1974 and the Resource Conservation and Recovery Act in 1976, the country has come to realize that the

Tripp *Continued on page 29*

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Jim Tripp is General Counsel with the Environmental Defense Fund in New York. He co-chairs EDF's Water Resource and Land Use Program and serves on the Advisory Committee for the Office of Technology Assessment's National Groundwater Study.

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Groundwater supplies about half the Nation's drinking water, and three-quarters of American cities get part or all of their water supplies from groundwater. Between 1 and 2 percent of the Nation's groundwater—which by quantity dwarves total surface-water supplies—is estimated to be contaminated by natural and/or anthropogenic sources. Contamination is most severe in areas of highest population density. What can be done about groundwater contamination, a problem expected to get increasing attention in coming years? And what roles should various institutions play in addressing the problems? Four perspectives:

Groundwater Contamination—A Play With Infinite Actors

by John M. Gaston,
CH2M Hill

The current mood among some drinking water industry professionals swings between abject confusion and a feeling of lurking deception. Just when we thought that the drinking water quality problems in the U.S. (bacteriological contamination, etc.) were on the run, a whole new class of contaminants appeared and provided an almost inexhaustible supply of new crises. I'm speaking, of course, of the all-too-frequent finding of groundwater contamination by organic solvents (trichloroethylene, etc.) and pesticides. But is there really a problem? Does this really point up a national issue or are these merely local incidents blown out of proportion? A recent survey* released by the U.S. EPA Office of Drinking Water indicates that of 945 wells sampled nationwide, 230 (24 percent) show some detectable level of one or more of the volatile organic chemicals. These were both random and non-random samples, (with the percentages higher in the second case), and they covered both large and small water systems in all 50 states. Some states came up clean (no positive samples), and some states found an alarmingly high percentage of positive samples.

Fine, you say, why is this such a big deal? How does this problem rank with other problems in the water utility industry? Current records show that there are about 59,000 community water systems in the U.S.

Gaston *Continued on page 31*

Protect Health and Environment While Maintaining Multiple Uses

by Steven I. Werner,
Occidental Chemical Corporation
and Chemical Manufacturers Association

Assuring a safe and adequate supply of drinking water is, and should be, one of the highest national priorities. Assuring that minimum national standards are met is the goal of the Safe Drinking Water Act, and significant progress has been made toward that goal. Groundwater is an important resource that contributes significantly to the economic well being of the Nation. As a society, we historically have enjoyed a wide variety of groundwater uses, and it is reasonable to assume we will continue to in the future.

Increasing use of groundwater and rapidly improving monitoring and analytical capabilities have increased national attention to groundwater quality and quantity. Few individual governmental entities are organized to respond to the need for comprehensive and coordinated groundwater management. Such a comprehensive approach is needed to assure we do not adversely affect this valuable resource.

There is a need for comprehensive groundwater management, an approach that can protect public health and the environment while responsibly maintaining multiple uses of the resource. The concept of groundwater classification according to its present and projected uses is practical and technically feasible. A groundwater use-based classification system provides individuals responsible for managing the resource with a basis for planning and action. Such a system establishes reasonable priorities while

Werner *Continued on page 32*

John Gaston is Senior Consultant on CH2M Hill's Water Quality and Treatment study for the East Bay Municipal Utility District and the Contra Costa Water District, and Project Manager on a water quality study involving the Metropolitan Water District of Southern California and their member agencies. He previously was Chief, Sanitary Engineering Branch, California State Department of Health Services.

Steven I. Werner is Manager, Environmental Programs, Corporate Environment, Health, and Safety at Occidental Chemical Corporation. He serves as Chairman of the Chemical Manufacturers Association's Ground Water Management Task Group.

Williamson ***Continued from page 26***

in rivers that form the source of supply for surface water appropriators. Throughout the Nation, greater emphasis is being placed on overdraft problems.

Unfortunately, less attention has been paid to—and less is known about—groundwater pollution. The conventional wisdom has been that nature protects groundwater quality much more than it actually does. It is now better recognized that aquifers do *not* provide the natural dilution or flushing that occurs in surface waters. A contaminant that penetrates the aquifer tends to form a "plume" of highly contaminated water, moving slowly through the aquifers for years, even decades. Many of the contaminants found are damaging both to human and animal health. Furthermore, the contaminants are difficult or next to impossible to remove once they have been mixed with groundwater.

> *'Federal policy does not address groundwater from a consistent consolidated standpoint.'*

So far, only a fledgling effort has been made to come to grips with the groundwater quality issue. Superfund has brought recognition to the problems caused by hazardous waste disposal sites. Agricultural chemical leaching in coarse-textured soils is better understood. The Safe Drinking Water Act (SDWA), with provisions for underground injection control and sole source aquifer protection, will be helpful. The Resource Conservation and Recovery Act (RCRA) will provide control for certain hazardous practices.

All of these are positive steps forward, but much remains to be done.

While developing a 1983 White Paper on Groundwater Management, the Interstate Conference on Water Problems (ICWP) reviewed the groundwater management arena and found a number of things lacking. ICWP stated that effective state groundwater programs have been hampered by federal programs that are administered through separate federal agencies with little or no coordination. ICWP participants also commented that many "programs fail to recognize the inter-relationships between water quantity and quality." Generally, members felt that federal policy does not address groundwater from a consistent consolidated standpoint.

ICWP participants also offered some strong advice to its state members. They argued that states make a concentrated effort to manage their groundwater resource. While the problems of groundwater overdrafting and pollution are localized, both are problems of national significance. Even though many states have the statutory framework within which effective groundwater resources management can be developed, a more reliable accounting system of state and local progress on groundwater management—both water quality and quantity issues—needs to be devised. State policies differ greatly and many

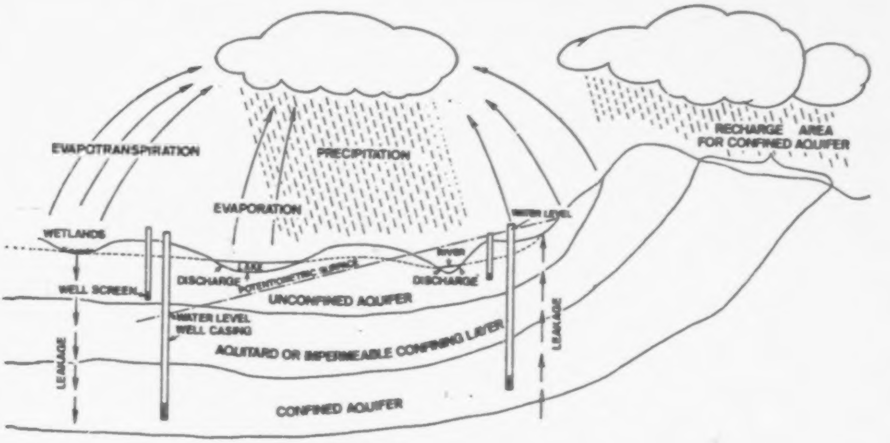


Illustration of Relationships Within the Hydrologic System.
Source: Groundwater Contamination in the United States. *University of Pennsylvania Press, 1983.*

improvements are needed. Increasing demands for groundwater point up the desirability for numerous changes in laws and institutions at *all* levels of government.

With unanimity, state water leaders have pointed out that the data base for groundwater must be improved. A basic groundwater monitoring system with an aggressive groundwater quality sampling program is needed to establish baseline information. Water sampling must be maintained on a continuing basis to indicate trends in water quality changes. Supplies and qualities of groundwater reserves must be determined, and responsible planning provided for their continued use. Effective and efficient strategies must be designed to aid users with management techniques. It is unlikely that much progress toward a total water management philosophy can be made unless all aspects of water are considered in concert.

A decade ago, the National Water Commission said, "Groundwater pollution has long-term and sometimes irreversible effects; the consequences of aquifer pollution may be to place greater demands on other sources of water. The Commission believes that the subject is of national concern." After 10 years, the statement still rings true, but there has been little coordinated effort to curb the problem.

Without a doubt, all levels of government need to become more active in groundwater management. Laws will have to be improved. Additional research will be necessary. More technical data and information about groundwater resources will also be necessary for management decisions. Although states are always shy of an increased federal role, better coordination and increased federal effort is a must. With additional emphasis at the federal level, state and local governments will sharpen their focus and develop groundwater protection strategies.

Coordinated effort between all levels of government, business, industry, and agriculture is a must.

Attitudes may have to change. Groundwater classification systems must be considered. Limited degradation of groundwater supplies in some areas may be necessary. However, in certain agricultural areas, it may be more economical and practical to import a domestic water supply than to preserve the entire aquifer for non-agricultural use.

In summary, positive steps must be taken to avoid future groundwater contamination problems. All of the actions described will take additional dollars. Monitoring groundwater levels and providing a continuing chemical analysis program will be expensive. Research costs may even surpass the cost of the data-gathering effort. Likewise, management activities will not be cheap. Finally, the leadership role must be established. A coordinated team effort between all levels of government, business, industry, and agriculture is a must. State government should come to the forefront to lead this challenge. ☐

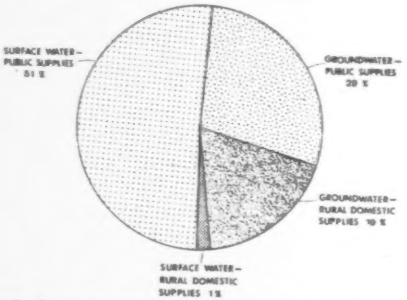
Tripp *Continued from page 26*

amount of hazardous waste generally, the number of abandoned and existing sites for disposal of toxic industrial and municipal wastes, and the quantity of household and agricultural contaminants entering groundwater are far larger than was known in the mid-1970s.

Further, the fact that groundwater pollution is invisible and ubiquitous, that its residence time is so long, and that toxic contaminants are now known to penetrate what was once considered a protective soil mantle—these factors make it both insidious and feared. These basic facts about groundwater and its pollution mean that the public demand for a larger federal role will inevitably increase, as will the need for stronger state programs.

Although much of the federal role under RCRA and Superfund relates to monitoring, clean-up of abandoned hazardous waste sites, and limited control of major existing pollution sources, the federal role in *preventing* groundwater pollution must also expand. Because clean-up of pollution is so complex and costly, the virtues of prevention, through protection of recharge watersheds and control of siting of pollution sources, are obvious. An expanded federal role in preventing groundwater degradation will involve amendments to statutes, increased funding, more emphasis on the siting of point and non-point sources of groundwater pollution, and support of state groundwater watershed protection programs.

Population Served by Source and Supply, 1970.



What kind of federal action is needed if the national objective calls both for the maintenance and restoration of the integrity of the Nation's groundwater, and encompassing effective clean-up, source control, and prevention strategies?

Clean-Up and Control

As far as clean-up is concerned, the number of abandoned sites which qualify for Superfund funds will increase, and the cost of cleaning up those sites so they would comply with applicable standards, may be much closer to the Office of Technology Assessment estimate of $10 billion to $40 billion than to $2 billion. The federal commitment must therefore be clearly articulated, and a funding program commensurate with that commitment designed. More funds certainly will be required.

As far as control is concerned, EPA RCRA regulations must be tightened to control groundwater contamination from existing sources, and not just from new ones.

Prevention

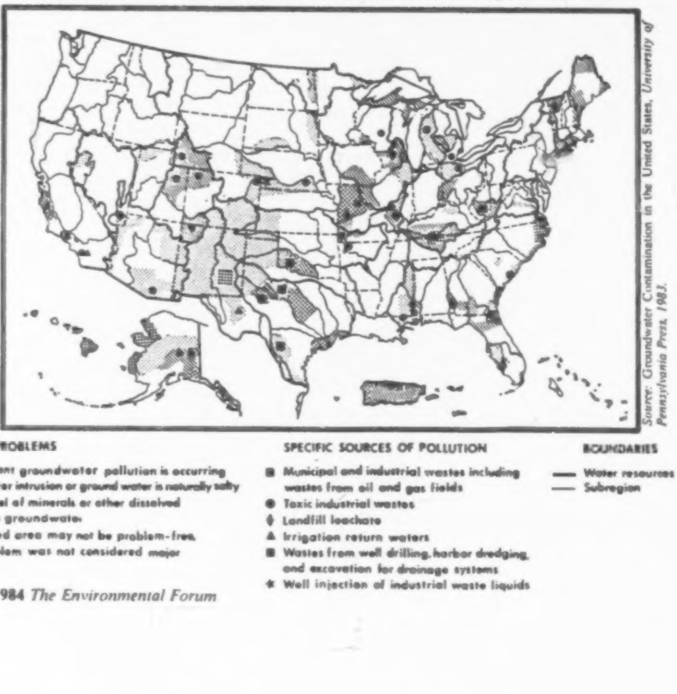
Congress and EPA must take several steps on the prevention side of the equation. First and foremost, the federal role should include the promotion of local, state, and national processes for development of groundwater recharge watershed protection programs.

Within a recharge watershed protection framework, we have to recognize that the siting or location of a source of groundwater contamination is a critical factor in assessing the likely impact of that contamination. Thus, much more federal attention must be paid to siting criteria within this context. EPA should develop under RCRA and the Safe Drinking Water Act siting criteria for use in state or local programs for hazardous waste facilities, landfills, and underground injection wells. Further, EPA should develop criteria for imposing siting or geographic constraints on toxic chemicals subject to the Toxic Substances Control Act and the Federal Insecticide, Fungicide and Rodenticide Act review, recognizing groundwater recharge zone characteristics. The individual or synergistic effects of household solvents, fertilizers, and pesticides can be far greater in a primary watershed area with sandy soils recharging to high-quality groundwaters than in other areas.

Further, Congress and EPA should strengthen the SDWA sole source aquifer program, both to stimulate local or state processes for the recharge area protection, and to strengthen federal and, by delegation, state or local control over public infrastructure investments. A bill now pending in the House, H.R. 79, would promote such processes.

At the same time, we have to recognize that reliance on SDWA drinking water regulations is inconsistent with a prevention strategy. Those regulations simply condone significant degradation of

Groundwater Pollution Problems (As Identified by Federal and State/Regional Study Teams).



Source: Groundwater Contamination in the United States, *University of Pennsylvania Press, 1983.*

AREA PROBLEMS
▨ Significant groundwater pollution is occurring
▤ Salt-water intrusion or ground water is naturally salty
▭ High level of minerals or other dissolved solids in groundwater
☐ Unshaded area may not be problem-free, but problem was not considered major
SPECIFIC SOURCES OF POLLUTION
■ Municipal and industrial wastes including wastes from oil and gas fields
● Toxic industrial wastes
♦ Landfill leachate
▲ Irrigation return waters
■ Wastes from well drilling, harbor dredging, and excavation for drainage systems
* Well injection of industrial waste liquids
BOUNDARIES
— Water resources region
— Subregion

high quality groundwaters. Therefore, EPA should develop a two-tier set of standards—one linked to control of polluted drinking water sources, the other to preventing degradation of high quality groundwater.

Finally, on the prevention side of the equation, the federal government should establish processes and schedules for phasing out land or underground disposal of hazardous wastes. It must create incentives to pursue alternative strategies which won't simply transfer degradation from groundwater to some other medium. Both H.R. 2867 and 3200 contain provisions which move in this direction. All of these prevention-oriented steps entail a larger federal role in preventing degradation of groundwater. This heightened federal role is also important to promote and support local and state programs.

Two other steps are needed. The federal research role must be greatly strengthened. Much more funding is needed for scientific research on monitoring, detection, health impacts, aquifer classification, recharge area delineation, innovative hazardous waste control technologies, land disposal alternatives, residential disposal systems, and integrated pest management.

Finally, federal enforcement mechanisms must be strengthened. Congress should establish administrative and judicial processes available to water suppliers and other beneficial users of groundwater to block or control introduction of toxic contaminants, nutrients, or salts from point and non-point sources. Under the SDWA, for example, if a water supplier has a source which does not satisfy regulation, that supplier may have to install treatment systems at some cost. Alternatively, under the SDWA, a water supplier should be authorized to compel EPA or state investigations of sources of contaminants of concern—with a view toward requiring more stringent controls under the Clean Water Act, RCRA, the SDWA, or other programs. H.R. 3200 contains provisions which are a tentative, although far from adequate, step in this direction.

In summary, the federal role must be expanded to facilitate establishment of effective recharge watershed programs within which siting criteria, geographic constraints, and land use controls play key roles in protecting groundwater. ☐

Gaston ***Continued from page 27***

Approximately 6,000 (10 percent) of those systems suffer from either chronic or persistent bacteriological contamination problems. In addition, somewhere between 1,000 and 3,000 systems (1.7-5 percent) have inorganic chemical problems (nitrate, fluoride, arsenic, selenium—generally naturally occurring). So even if we add these two *most prevalent* problems together we still fall short of the 24 percent problem that *may* exist with volatile organic chemicals.

Do we need new laws? More money? No and yes, or yes and yes.

The debate as to how we got in this position appears to be endless, and while the reasoning over the fault of the various parties is interesting, it won't help us today. How best can we use existing resources to find the problems and correct them once found? The players in this little drama appear to be: The federal government (U.S. EPA); state and local governments; water utilities; industrial concerns that use, dispose or produce these compounds; and, of course, consumers. Bit players include the courts, the lawyers, the laboratories, the fourth estate, and a host of others.

- *U.S. EPA:* Its current role is to conduct national surveys, such as the Groundwater Survey; provide health effects advice to states; develop and adopt regulations to control drinking water contaminants, and, in some areas, actually run the regulatory programs in the states. This is an appropriate role; few will argue that where the occurrence and health effects data show justification, these compounds should be regulated. EPA's current resources do not appear adequate, and lack of funding will slow or even stop the process.
- *State/Local Governments:* Traditionally, the day-to-day running of the regulatory program for all drinking water contaminats has been the role of the states. They enforce the regulations developed by the EPA; provide sampling, inspection, training, etc., for the water utilities; and tailor the regulatory program to fit the needs of the particular state. This, too, is the right role; states should not (and cannot) develop national standards and national policy. They do need resources to provide "hands on" help to utilities.
- *Water Utilities:* This is the group that feels most deceived. At last the big problems were on the way out and *bang* . . . up jumped the groundwater issue. This group needs good advice and leadership, both from within and from the outside. Utilities need to know that if they find an unknown, unpronounceable chemical in their system, the state (or someone) will provide them advice on health effects and treatment as quickly as possible—or sooner. Their needs are really the same as the EPA and state needs, but they also have a need for leadership within the water utility profession to ensure that they do not re-invent the wheel.
- *Industry:* This group has an obligation to help out when a problem is found. In fairness, many of the groundwater problems we see today were

caused by dumping that occurred long ago, and the culprit has long since disappeared. Industry should take an active role in health effects research, treatment techniques and, most important, in the prevention of future problems. They are an integral part of the problem and the solution.

- *Public:* It must be terribly confusing for the public to be faced with an almost constant assault of bad news about drinking water problems. Their collective obligation, if one indeed exists, is to be informed, active, and supportive of the utilities, and to take a continuing interest in all drinking water issues—not just the bad news.

What do we need to pull this all together and correct the problems? New laws? More money? No and yes, or yes and yes. Current drinking water statutes are sufficient to allow the EPA to regulate these compounds in drinking water. The resources do not exist to develop the necessary health effects and occurrence data for the host of compounds that may find their way into the water supply.

The real question to which no answer exists is: "When will we turn the corner and start seeing a decline in the occurrence and concentration problems that now appear on a day-to-day basis?" ☐

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* *The Groundwater Supply Survey—Summary of Volatile Organic Contamination Occurrence Data. U.S. EPA Office of Drinking Water. January 1983.*

Werner ***Continued from page 27***

accommodating differing occurrences and uses of groundwater. This is done by: a) recognizing existing groundwater uses; b) projecting future uses; c) accounting for the occurrence, availability, and chemical and biological quality of groundwater; and d) ensuring that different uses of the same groundwater are compatible. Those who use groundwater, whether by withdrawal or recharge, would be responsible for the protection of the resource within its classified purpose.

The flexibility of this groundwater management system allows it to be successfully applied on a micro- and a macro-geographic basis. In this way, protection of the resources will be maintained while, with appropriate types of controls, other uses of groundwater and land surface can coexist. The concept of classification is not a solution in itself but a useful tool in a comprehensive groundwater management plan.

A national groundwater policy is needed that requires federal environmental laws covering groundwater to be administered in a consistent fashion. Congress already has taken several important steps toward protecting our groundwater resources. Major environmental legislation has been designed to control potential discharges to aquifers. Acts such as the Clean Water Act, Resource Conservation and Recovery Act, Safe Drinking Water Act, and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) are reducing and controlling industrial, commercial, and municipal facility discharges that contribute to groundwater contamination. These control measures, however, do not yet thoroughly address nonspecific source discharges resulting in area-wide groundwater problems.

At the state level, many states' water pollution control statutes extend to groundwater. Many states also have specific statutory authority to develop groundwater management systems. Most western states have implemented general permit systems for allocating the quantity of groundwater. A few eastern states have followed suit, although quantity is generally not a priority because of an abundant water supply. Very few states have implemented or adopted groundwater policies that comprehensively address both the management of quantity and quality of groundwater resources within their jurisdiction.

Protection of health and environment while maintaining multiple uses should be EPA's primary groundwater goal.

Individual states should have the primary responsibility for implementing groundwater policy. The federal role in groundwater policy should be to identify a broad national goal, develop use classes, and provide supplemental technical and financial assistance to states so that states can carry out their management programs. The states have the sole right of water allocation and therefore the sole right to assign the use classes and determine appropriate management techniques. The states should also be aware of the need for regional cooperation. The federal government role should be one of advisor, funder, and supplier of technical assistance and scientific information.

Our Nation's groundwater supply is huge. By promptly enacting a comprehensive management system we will be able to preserve that resource for all of its potential uses. The Environmental Protection Agency has been working to develop a groundwater position paper and has determined that groundwater will be one of its priority activities in fiscal 1984 and 1985. Protection of human health and the environment while responsibly maintaining the multiple uses of the resources should be one of the agency's primary groundwater goals. ☐

POINT . . . AND COUNTERPOINT

SETTING DRINKING WATER STANDARDS

Business As Usual Won't Do; Status Quo 'Too Risky'

by Rep. Dennis E. Eckart,
(D-Ohio)

In 1974 Congress enacted the Safe Drinking Water Act and handed the U.S. Environmental Protection Agency a mandate to protect the quality and purity of the Nation's drinking water. Nearly a decade later, the mandate is unfulfilled, even though EPA was given virtually unlimited implied discretionary powers to fashion effective standards and regulations.

Too few standards and regulations have been put into effect. Even these standards and regulations, based on out-of-date public health information and water treatment technology, are virtually useless. And compliance is the exception, rather than the rule.

Since Congress passed the 1974 Act, we have discovered more than 700 organic chemical contaminants in already treated drinking water supplies around the country. Many of these contaminants are hard to detect. Many are colorless and odorless and have no taste. Health problems linked to their ingestion vary from simple nausea, body tremors, and blindness at higher concentrations to disorders of the nervous system at lower doses.

Measuring absolute risks of cancer is, of course, difficult and uncertain. But there is ample research to suggest that certain chemical contaminants do increase significantly the risks of certain cancers. Of the most frequently discovered chemical contaminants in our drinking water supplies, researchers have identified at least two as causing cancer in

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Congressman Dennis Eckart (D-Ohio), a member of the House Energy and Commerce Committee, has proposed fundamental reforms to the Safe Drinking Water Act (H R 3200)

Flexibility Needed to Address Problems Quickly

by Rep. Edward R. Madigan,
(R-Illinois)

Contamination of our precious sources of drinking water has become a major concern to the people of this country. With the increase in our ability to measure the presence of man-made and natural chemicals in our water supplies down to the parts per quadrillion, we are discovering that even the purest drinking water contains some contamination. As we move towards a long-overdue reauthorization of the Safe Drinking Water Act (SDWA), we must devise a way by which EPA can address the problems posed by drinking water contamination quickly and effectively, before pollution of our groundwater becomes an even more serious and alarming national problem.

H.R. 3200 Will Hinder Action

One bill has been introduced in the House of Representatives this Congress to reauthorize the Safe Drinking Water Act—H R. 3200. Although this bill properly identifies some of the areas of the law in need of change, it adopts absolutely the *wrong* approach in the area of standard setting.

H.R. 3200 would require the Administrator of EPA to promulgate regulations within a strict time period for 14 volatile organic compounds (VOCs), and for all 127 pollutants listed under Section 307 of the Clean Water Act. Congress does not have the expertise to arbitrarily list contaminants and then require regulation. In fact, if adopted, this rigid

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Congressman Ed Madigan represents the 15th District of Illinois. He is the Ranking Republican on the Subcommittee on Health and the Environment, which has jurisdiction over the Safe Drinking Water Act, and the Ranking Republican on the Committee on Agriculture.

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Congress for the past several months has been considering the first substantive amendments to the Safe Drinking Water Act since that law was enacted in 1974. In the House in particular, a major sticking point has revolved around the setting of contaminant levels for chemical pollutants found in drinking water. The current system under the Act, under which EPA has set very few contaminant standards, basically pleases no one. The following four key interests in the debate address ways in which the standard-setting process might be reshaped:

Better Risk Assessment Methods, Clear, Enforceable Standards Needed

by Donald R. Boyd,
Association of Metropolitan Water Agencies

The public expects to receive water that is safe, reasonably priced, and pleasant to drink. People expect scientists and regulators to develop standards which will protect their health, and which allow them to evaluate the quality of their water. The approach set forth in the Safe Drinking Water Act (SDWA) does not accomplish these ends. The Act requires the establishment of two separate sets of standards for drinking water: first, recommended maximum contaminant levels (RMCLs) are to be set at a level at which no known or anticipated adverse health effects occur; and then subsequently, Maximum Contaminant Levels (MCLs) are to be set as close to the RMCLs as feasible, taking technological and economic constraints into account. The MCLs would be enforceable standards; the RMCLs non-enforceable goals.

The Association of Metropolitan Water Agencies (AMWA), which represents 43 of the largest municipally-owned water supply systems, strongly supports the establishment of stringent, enforceable MCLs. For those compounds for which the harmful level of the substance is known, the MCLs must be set at a level at which no adverse health effects occur.

Regulating substances that are suspected or known carcinogens presents a much more difficult problem. Current toxicological risk assessment methods cannot determine whether low levels of carcinogens are safe or unsafe. Only "absolute zero" satisfies the wording of the Act for carcinogens. As it is neither

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Donald Boyd is President of the Association of Metropolitan Water Agencies, and Director of the Pollution Control Department, City of Kansas City, Mo.

SDWA Amendments Needed to Respond to Local Needs

by John M. Capriccioso,
Halogenated Solvent Industry Alliance

The most important needed change in the Safe Drinking Water Act is to require development of a process that will result in the determination of acceptably safe exposure or contaminant levels for chemicals that may be found in drinking water.

With the increase in analytical sensitivity and the increased frequency of monitoring water supplies, a variety of manmade and natural chemicals will continue to be identified in drinking water at low concentrations. The public needs to know in a timely manner whether or not that contamination truly poses a significant risk to human health. This is the most important question, and it must be answered with objectivity. The public does not need to be unnecessarily alarmed, but it does need to know whether the level of contamination requires an emergency response or whether there is time to develop an efficacious process for cleaning the water to the extent necessary (based on health considerations and scientific data) or desired (based on aesthetic or other considerations) by the affected populace. Ultimately in either case, the overall welfare of the public can best be served if a concentrated effort is made as early as possible to understand the scientific data available on substances detected in the public's drinking water.

Under the current Act, EPA has authority to establish recommended maximum contaminant

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John Capriccioso, with Dow Chemical Company's inorganic chemicals operations in Midland, Mi., chairs the Halogenated Solvent Industry Alliance—Water Work Group, which represents U.S. producers and many users and distributors of such chlorinated solvents as 1,1,1-trichloroethane, perchloroethylene, methylene chloride, and trichloroethylene.

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human beings. Ten are known to cause cancer in animals, and more than a dozen have yet to be tested thoroughly. Add the potential threat of birth defects and we are confronted with a serious national problem.

When Congress passed the 1974 Act, it assumed that EPA would make effective use of its broad implied discretionary authority. Congress thought EPA would take seriously its instructions to give protection of our drinking water supplies the highest priority. Further degradation of drinking water was to be resisted on every front. EPA's regulatory machinery was supposed to function smoothly. At least that's what Congress thought and intended nearly a decade ago.

EPA study 'a ringing indictment of the agency's ineptitude and neglect.'

Yet today we are worse off. Instead of reducing and working to eliminate the threats of chemically-contaminated water supplies, especially groundwater which is so vulnerable, the agency's intransigence and neglect have steered us in the opposite direction.

A study by EPA shows that 29 percent of the drinking water of larger communities contain chemical contaminants. The study is a ringing indictment of the agency's ineptitude and neglect.

If that study isn't enough of an indictment, consider that the National Academy of Sciences has reported instances of "serious chemical contamination" of groundwater in 34 states. Scientists at Cornell University also report that at least a half-million rural families drink water that fails to meet simple standards for bathing at public beaches.

Consider, too, that 150,000 of the 181,000 known land impoundments containing toxic chemical wastes and other kinds of wastes are a mile or less from groundwater or surface water supplies. Of the 419 original toxic chemical wastes on the EPA's "Superfund" clean-up list, 347 are rated serious threats to water supplies. As a society we are learning from costly and bitter experiences that the ground is not a simple sponge capable of endlessly soaking up toxic chemical wastes without eventually leaking into groundwater supplies and lacing them with a veritable carcinogenic stew.

Clearly, it's time for Congress to put EPA on specific notice to begin prohibiting any further land disposal of dangerous toxic chemical wastes, particularly those which are turning up in our drinking water supplies. And it's time for Congress to enact some fundamental reforms of the 1974 Safe Drinking Water Act.

One bill reauthorizing the 1974 Act proposes a departure from our past practice of extending the EPA implied and almost unrestricted discretionary powers. Instead of providing implicit instructions, the bill gives the agency explicit and specific instructions and priorities to set standards for safe limits on those chemical contaminants most frequently found in drinking water supplies.

EPA record demonstrates Congress must list contaminants to be regulated.

Congress unfortunately can no longer rely on EPA to act on its own to establish effective standards and regulations. EPA's record since 1974 clearly demonstrates the need for Congress to submit to the agency a list of chemical contaminants for which standards should be written. Congress also needs to set strict deadlines and priorities to assure that its intent is eventually complied with.

In reforming the 1974 Act, we must do more than just lead the EPA to water. We must get EPA to regulate effectively to protect the public health from the potential insidious consequences of chemical contamination. Business as usual is no longer acceptable. The status quo is too risky.

The reforms proposed also require more frequent and routine testing and monitoring of drinking water supplies, both public and private. Only when we have more testing and monitoring will the government have the proper data to determine more precisely which chemical contaminants need regulating and which can go unregulated. There is not enough data to allow EPA to regulate based solely on frequency of occurrences.

. . . frequency of occurrence data lacking . . .

The proposed reforms also offer an opportunity for the federal government to shape what the National Academy of Sciences says is a must if we are to deal effectively with present and future sources of contamination: a flexible and well-integrated national strategy in cooperation with the states.

Protecting our drinking water supplies is not only important for reasons of public health and welfare. Our water supplies, especially in my region of the Nation—the Great Lakes area—are essential for attracting economic growth.

The real issue in reforming the 1974 Safe Drinking Water Act does not involve the federal government's engaging in some regulatory mischief making. The issue is simple: guaranteeing the quality and purity of a life-sustaining precious resource and ensuring that the government doesn't have to pin a label on the water faucet warning Americans that what they get might be hazardous to their health. ☐

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approach would very likely weaken the law's ability to protect the public health.

Why should EPA waste its time and resources promulgating regulations for contaminants which, first, may not even harm people, and second, are not high priority contaminants because of low frequencies or levels of occurrence? What is needed instead is a flexible process which allows the expert agency to give priority to some contaminants and direct resources to the most serious problems first.

Flexibility Needed to Spot Problems, Ease Responses

EPA must never be required to regulate contaminants arbitrarily unless it finds that the substance may harm the health of people. I do not object to the agency's examining the 14 VOCs listed in H.R. 3200, because these generally have been identified as potential problems. But regulation should occur only for those which meet the statutory health criterion. In fact, EPA plans to promulgate regulations for nine of the 14 contaminants. According to the agency, there is no health basis for regulating the other five.

As to other contaminants, EPA should periodically publish priority lists of those substances that need to be examined. Regulations should be proposed first for those that pose the most serious health problems. These decisions obviously should be based on the frequency with which the contaminant is found in drinking water supplies and the level of occurrence throughout the country. These regulations should be issued as quickly as possible. To ensure this quick action, the statutory requirements concerning standard setting must be changed.

Promulgation of Recommended Maximum Contaminant Levels (RMCLs) merely delays the effectiveness of the enforceable standard, thus potentially placing the public health in jeopardy longer. In any standard-setting process which allows for feasibility, the regulatory agency certainly must first determine the ideal level for protection of human health before applying the feasibility criteria. To require the agency, however, to *publish* this idealistic goal, with its accompanying procedural requirements such as notice and comment periods, merely delays the implementation of the enforceable standard. It makes more sense to quickly promulgate, subject to all procedural protections, a rational achievable standard. Standards then should be periodically reviewed and made more stringent as technology improves.

A final, important piece of this flexible, expedited standard-setting scheme is some method of emergency response to localized problems. To date, EPA has issued 22 SNARLs (Significant No Adverse Reaction Levels) or health advisories, which lay out a suggested contaminant level which the affected state or locality can adopt to protect the health of its citizens from this localized situation. Health advisories are not authorized specifically in the SDWA. Those which have been issued have never been subjected to scientific peer review, but have often been widely distributed and enforced. These health advisories could become a very important aspect of the Act if we properly authorize them in the statute and provide some guidance as to their use.

The EPA Administrator should have the authority to determine that a contaminant, while it may pose an adverse effect on the health of persons, is best-addressed by a health advisory because of its very localized effect, and/or because it poses such a serious potential health risk that it must be addressed immediately. These advisories should be issued on a temporary basis. At the same time, EPA should initiate a scientific review of the advisory by its Science Advisory Board. Public comment on adverse health effects should be received. After this scientific review, the administrator should issue a *final* health advisory, which may or may not be the same as the temporary advisory. In the meantime, the temporary advisory is out there addressing the localized or emergency health problem.

'Demanding only national standards may jeopardize public health'

I can perceive two objections which might be raised to the issuance of health advisories. First, some people might say that EPA will view this as an "out" to avoid the promulgation of national standards. Second, it may be charged that any avoidance of the standard-setting process detracts from the health-based aspect of the Act. Both of these objections can be easily addressed.

There is no reason that promulgation of a national standard should be the *only* way that EPA can address a drinking water contamination problem. A very localized problem or emergency situation can best be handled through an immediate response. But, to ensure that EPA does not abuse this tool, issuance of a health advisory should merely be the *first* step in the decision process towards the setting of standards. After issuance of a health advisory, that contaminant would be added to the priority list and considered a candidate for an MCL if the administrator determines that the statutory criteria are met.

As to the health-based aspect of the Act, under this scheme the administrator must *first* make the determination that the contaminant "may have an adverse effect on the health of persons." *All action would be based solely on a finding of adverse health effects.* The health-based aspect of the law should not be compromised. The administrator then would have to either promulgate a national standard or, if the problem is localized or an emergency situation exists, issue *a health advisory*.

In summary, a flexible standard-setting scheme must be established. The administrator must be allowed to judge contaminants for regulation so that those posing the greatest risk are addressed first. We must streamline the regulatory process through elimination of RMCLs so that potential health problems are attacked quickly, and the administrator must be allowed to address extremely localized or emergency situations through health advisories. I favor quick reauthorization of the Safe Drinking Water Act and urge movement on this issue. The American people are demanding a quick federal response to the problem of contamination of drinking water, and we can guarantee that response by adopting these much-needed changes. ☐

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technologically nor economically feasible to completely eliminate all suspected carcinogens from water supplies, the MCLs for carcinogens will have to be different from the RMCLs.

Existing standard-setting process results in confusion

The establishment of different RMCLs and MCLs for carcinogens not only will fail to increase public health protection, but will result in public confusion and misunderstanding about the safety of water supplies. This confusion will result in exploitation of the public by industries that profit from public mistrust of municipal water quality: the bottled water companies and manufacturers of home treatment devices. We believe that the public interest will be better served if EPA adopts one clear set of enforceable standards and expends more effort on developing sound risk assessment methods for carcinogens.

Well-funded research needed to put standard setting on scientific footing

When the SDWA was passed in 1974, legislators did not anticipate the difficulty in obtaining absolute certainty of no adverse health effects from low levels of carcinogens. EPA was directed by the Act to obtain a contract with the National Academy of Sciences to prepare a report which would evaluate and explain the impact of exposure to low levels of contaminants from water and to recommend maximum contaminant levels for water. Congress set a deadline of two years after passage of the Act. It is now 10 years later, and the difficulty of obtaining this information is demonstrated by the fact that it still is not available for any suspected carcinogens.

AMWA recommends that the EPA establish enforceable standards (MCLs) as quickly as possible, based on available health effects data, available technology, and costs for many compounds where adequate data currently exists. In conjunction with the development of these MCLs, AMWA proposes also that Congress amend the Safe Drinking Water Act to establish a parallel research program, with adequate funding, under the direction of the National Academy of Sciences or other organizations designated by the Congress. This research effort would have three major components: first, to conduct within three years further health effects research to assist in establishing water quality goals for the standards for which adequate data already exists; second, to conduct on an ongoing basis health effects research on other potential contaminants for the purpose of establishing enforceable national standards and water quality goals; and third, to review water quality goals on a regular basis to provide EPA with the necessary, current data to support, review, and revise national standards as appropriate.

Municipal water supply agencies are eager to do their part in providing safe, high quality drinking water to the public. We are deeply concerned about the existing cumbersome standard-setting process which has resulted in confusion and, most importantly, major delays in the develpment of national standards for drinking water contaminants. Our approach would result in the rapid development of national standards for all drinking water constituents found to have adverse health effects. The creation of a well-funded, major research effort would also serve to place the standard-setting process on a firm, scientific footing. In the final analysis, our approach would provide Congress with a vehicle for forging a compromise and moving ahead with Safe Drinking Water Act reauthorization legislation that should satisfy the concerns of all interested parties involved in the current debate. ☐

Capriccioso ***Continued from page 27***

levels (RMCLs), which are to be health goals, and maximum contaminant levels (MCLs), which are standards. Although the clarity of the EPA's statutory directive may be debated, EPA has not established any RMCLs and few standards or final MCLs.

The Office of Drinking Water at EPA, however, has developed an informal program which produced advisory documents called Suggested No Adverse

Response Levels (SNARLs). These SNARLs now are referred to as Health Advisories (HAs). They were developed under the technical assistant provisions of the current statute with little or no definitive direction by Congress. Approximately 22 such health advisories have been issued by EPA, indicating a high level of activity in developing HAs as compared to RMCLs and few standards. In the opinion of the HSIA, timely health advisories are an important output from the Office of Drinking Water at EPA if the public's health is of concern. However, there are two major problems with the Health Advisories issued to date.

'Reflect local needs as well as national concerns'

First, many of them did not take into account all available scientific data when they were published; second, they have not been revised, so some advisories published several years ago do not consider important recent data. Although these HAs are not legally enforceable standards, experience tells us that the concentrations reflected in the HAs will, in many cases, be adopted by local and state authorities, and possibly by courts, as levels for triggering emergency response. In effect, they become standards. Amendments to define HAs as a replacement for RMCLs will improve the current process and clear up confusion.

Any program developed to protect drinking water must reflect the fact that there are local needs as well as national concerns. Flexibility should be built into the program so it can be used appropriately under varying circumstances, to result in a credible, publicly acceptable process for establishing acceptable contaminant levels.

Health Advisories must reflect important recent information

There have been a number of seemingly unique observations of various contaminants in drinking water. EPA needs to be able to react to these situations, and a properly designed health advisory program can meet that need. Because these advisories are designed to address human health concerns, independent scientific review of the advisories should be adequate to address the health goal concept—rendering RMCLs as unnecessary and, in fact, perhaps counterproductive. Peer-reviewed health advisories likely would be more readily accepted and used more voluntarily as health goals. Although most current health advisories need updating and validation via formal peer review, state and local authorities already have substantial experience in using them.

Any new legislation should recognize that realistic and objective health advisories are the first and most timely step in the process of responding to observations of contaminants in a drinking water supply, be it a small well or a major water distribution system. The regulatory process should not stop there, however. A *Federal Register* request from EPA for information relative to the health advisory should initiate a formal scientific peer review process. In the meantime, local authorities could use the EPA's draft HAs to respond immediately to the situation identified as a concern. The *Federal Register* notice should set forth a date for review of the scientific basis of the proposed HAs. The notice should request comment on available health effects data for each contaminant, and in addition should request comment on exposure information; frequency of occurrence on a national basis; and other information which the Administrator believes may be pertinent to the potential establishment of a revised national primary drinking water standard for that contaminant. A Safe Drinking Water Scientific Advisory Committee should provide the Administrator an evaluation of relevant scientific data and of the conclusions in each proposed HA. If the committee finds the proposed HA is based on scientifically sound data and conclusions, the Administrator should promulgate a final HA.

Require formal scientific peer review draft health advisories

All current health advisories should go through this process, with subsequent changes as needed to put all HAs on a sound scientific basis. MCLs (standards) then could be developed as necessary to treat drinking water on a national priority basis and incorporate such concerns as treatability, economics, societal values, aesthetics, etc. HAs, once scientifically peer-reviewed and accepted, should be sufficient for use by other local authorities to address similar contamination concerns until standards are completed.

This proposal would provide for timely advice from EPA to local authorities by requiring EPA to draft a temporary health advisory to respond to that situation. Furthermore, it would require formal scientific peer review of that draft to assure that the best scientific input is obtained and incorporated in the final health advisories. The final health advisories then could be used to review the need for national standards on a priority basis. Such a program would incorporate, in a more defined manner, most of the program that EPA has under way. It provides for progression from a local emergency situation towards EPA establishment of priorities for standard setting. The approach would lead to an active program to help assure protection of human health from the consumption of drinking water—a significant improvement over the process in force at present. ☐

National Statistical Assessment of Rural Water Conditions

Summary

Executive Summary

Information about rural water conditions has long been fragmentary and incomplete. The information that existed generally has been limited to the results of unsystematic, localized surveys concentrated narrowly on a few prominent local water quality problems. These surveys have not generally employed compatible sample designs or methodologies. As a result, it has been difficult to formulate a unified understanding of rural water conditions, and difficult to devise informed, comprehensive policies and programs for rural water supplies.

To some extent, the absence of wide-ranging and detailed knowledge of rural water conditions is related to the nature of rural water supplies. Rural water systems are frequently individual and small multiple-connection systems, which fall outside the regulatory and funding programs of the major "water agencies" of government. With enactment of the Safe Drinking Water Act of 1974, Congress set in motion two major efforts to develop systematic, current data on rural water supplies across the nation. First, in response to growing concern with the quality of drinking water and its effects on human health, the Safe Drinking Water Act provided for a uniform, national set of water quality standards and extended the monitoring and regulatory responsibility of the US government over smaller water supplies. Second, the Act mandated a one-time national statistical assessment of the current status of rural domestic water characteristics.

The one-time study was to be an intensive examination of a wide range of factors, but for only a sample of households and systems. The institutionalized national monitoring program was to extensively cover a few factors on all community systems. This document is concerned with the intensive, one-time national statistical assessment of rural water conditions.

THE CALL FOR ASSESSMENT AND RESPONSE

The enabling legislation mandating the one-time assessment study was contained in Section 3(a) of the Act. It reads:

> Sec. 3(a). The Administrator of the Environmental Protection Agency shall (after consultation with the Secretary of Agriculture and the several States) enter into arrangements with public or private entities as may be appropriate to conduct a survey of the quantity, quality and availability of rural drinking water supplies. Such survey shall include, but not be limited to, the consideration of the number of residents in each rural area . . .
>
> (1) presently being inadequately served by a public or private drinking water supply system; or by an individual home drinking water supply system;
>
> (2) presently having limited or otherwise inadequate access to drinking water;
>
> (3) who, due to the absence or inadequacy of a drinking water supply system, are exposed to an increased health hazard; and
>
> (4) who have experienced incidents of chronic or acute illness, which may be attributed to the absence or inadequacy of a drinking water supply system.

The study called for in this provision of the Act has been completed and what follows is a summary of the five-volume, approximately 1,900 page report, submitted to Congress in conformance with the stipulations of the Act. The study and report, labelled the National Statistical Assessment of Rural Water Conditions (NSA), focused primarily on the quality, quantity, availability, cost, and affordability of domestic water in rural households throughout the continental United States. Additionally, some corollary information was presented on water systems serving these households.

RESPONSIBILITY FOR THE STUDY

Primary responsibility for oversight of the contents and conduct of the study was allocated to the US Environmental Protection Agency. Within EPA, the national assessment study was placed under the aegis of the Office of Drinking Water. The planning of the content, scope, and execution of appropriate procedures for conducting the study involved the Office of Drinking Water, various private consulting firms, university researchers, and professional organizations. Subsequently, proposals were solicited and a group of rural sociologists from the Department of Rural Sociology at Cornell University was selected to further conceptualize the study, oversee the sampling and data collection, analyze the results, and write the report summarized herein.

In Section 3(a) of the Act, the Administrator of EPA was directed to consult with the Secretary of Agriculture in the formulation and overview of the study. During the formulation stage of study, two meetings were held with a specially formed study group composed of representatives from Farmers' Home

Administration, Economic Research Service of the Economic Development Division, and the Statistical Research Service of the Statistical Division of USDA. The meetings were primarily devoted to discussions of (1) the general scope of the study effort, (2) the types of data to be collected, (3) the manner in which this study effort would complement and inform USDA programs and research, (4) a critique of the conceptual foundations of the study, and (5) the ways in which the data would be analyzed. In addition, FmHA representatives joined a review team composed of experts representing a spectrum of professions, interest groups, and government agencies. This review team met on three separate occasions to critique the analysis and report writing in progress.

SIGNIFICANCE OF THE STUDY

The study summarized here is the first national study designed to investigate the status of rural water quality at the point of use, in rural households. In addition, it is the first systematic national assessment of quantity, availability, cost, and affordability of rural domestic water supplies. It is the first national assessment of the links between the status of domestic water in rural households and characteristics of the supply which provides that water.

Prior to this study, the most complete information, at the national level, about rural water was contained in the Community Water Supply Study: Analysis of National Survey Findings, conducted by the Bureau of Water Hygiene, US Department of Health, Education, and Welfare (1970), and Survey of Operating and Financial Characteristics of Community Water Systems, conducted by Temple, Barker, and Sloane, Inc. for the US Environmental Protection Agency (1977). Studies other than these were either local in scope or examined water pollution in bodies of water located in rural areas, not the characteristics of the water at the point of consumption.

This study complements and extends the information from the earlier reports. But, its focus on the character of the water as it is actually consumed at the household differs from earlier efforts. Additionally, it uniquely provides complementary information about the water supply system. In short, it is the first national portrayal of rural household water conditions and associated system characteristics.

METHODOLOGY AND RESEARCH PROCESS

A review was undertaken of available information and procedures for studying the status of rural domestic water conditions. This review pointed up serious deficiencies in knowledge, conceptual maturity, and methodological tools. A conceptual reformulation and development of data collection procedures was undertaken by the Cornell research group. Members of this group developed the interview schedule in consultation with management and technical personnel at EPA, and with various representatives from other governmental agencies, consulting firms and research groups. The instrument was pretested and refined four times, and the final version was submitted and approved by the Office of Management and Budget.

Data collection involved, at each selected household, personal interviews with occupants, physical inspection of on-premises water supplies, drawing samples of the major household water supply, various observations on sources of potential contamination; and, where appropriate, separate interviews with managers and operators of off-premises water supply systems which provided water to these rural households.

TransCentury Corporation was selected by the EPA, after competitive bid, to administer the data collection activities. Oversight and general coordination of these activities was accomplished in coordination with the Cornell University research group.

Interviewers underwent a two-week intensive training course on all aspects of the data collection effort, including the drawing, packaging, labelling, and transportation of specimens of "tap" water. Quality control of the field work included constant and comprehensive monitoring. Data coders were also intensively trained and monitored.

Water samples collected at each household participating in the study were shipped to central laboratories for analysis of as many as 40 separate biological, physical, chemical, or radiological properties. Responsibility for these analyses was shared by several organizations including the Energy Resources Corporation, the Medical School of the University of South Carolina, the Mississippi State Chemical Laboratory, the EPA-MERL Laboratory (Municipal Environmental Research Laboratory) in Cincinnati, and the EPA-EMSL Laboratory (Environmental Monitoring Systems Laboratory) in Las Vegas.

The sampling plan for the study defined the target population to conform to the US Bureau of the Census' definition of rural population and households: civilian, noninstitutionalized persons located in unincorporated or incorporated places of less than 2,500 population, or located in rural areas not designated as a place. The sample was proportional to rural population (and households) in: (1) the four broad census regions—Northeast, North Central, South, and West; (2) located in areas designated as Standard Metropolitan Statistical Areas; (3) in rural communities of 2,499 to 1,000 population, under 1,000 population, or open country. The county was designated as the primary sampling unit. From the approximately 3,000 counties in the continental US, 400 were selected. Within those counties, a total of 2,654 households and their associated water supply systems were evaluated. They represented an estimated 21,974,000 occupied rural households. Of these, an estimated 8,765,000 households were served by individual, single connection systems; 2,228,000 households were served by 845,000 intermediate systems (two through fourteen connections); and 10,981,000 households were served by 34,000 community systems (fifteen or more connections). Total counts of households and systems were derived using standard statistical weighting procedures. Each unit's weight, in broad terms, was the inverted sampling fraction adjusted for nonresponse.

Collected data were compiled by the Cornell research group for statistical analysis and report production. All aspects of the report underwent extensive scrutiny by various review mechanisms.

MAJOR FINDINGS

This study considered five dominant dimensions of the status of domestic water: quality, quantity, availability, cost, and affordability. Rural residents were asked about health effects but the results were modest in that very few rural residents reported adverse health conditions which they associated with the water supply. Attempts to secure detailed information about the health effects of the water being consumed would have required a large-scale epidemiological investigation, which was not possible within the scope of this study.

Information was secured from both the households and water supply systems. The major findings and conclusions will be presented first from the household perspective, then from information collected at the systems.

WATER QUALITY

Water quality was assessed using as many as 40 indicators, including all of the contaminants given primary and many given secondary maximum contaminant levels (MCLs) by the EPA (see Table 1). The study used the MCL levels to establish benchmarks for comparing various segments of the rural population. These benchmarks, or reference values as they were called, were not totally isomorphic to the MCLs. The MCLs included components which could not be reasonably accommodated in the study such as: (1) retesting provisions; or, (2) in the case of fluoride, a range of MCL values. However, reference values were chosen to match the MCL specified level, whenever possible, to provide perspective on interpretation.

A quality assurance program was in effect in each of the participating laboratories. A follow-up attempt to secure results on the quality assurance was not entirely successful. Some records had been discarded, others were not in an easily usable format, and some were inaccessible. Quantification of the quality assurance results for the purposes of this report was not complete. However, there was no indication that quality assurance programs at the laboratories deviated from quality assurance procedures that were EPA-approved at the time of the NSA study.

The NSA investigation of rural water quality suggested problems of greater magnitude and prevalence (especially regarding mercury, lead, cadmium, silver, and selenium) than had been generally expected, based on data from monitoring community water systems and from other studies. Since it is the first nationally systematic consideration of rural domestic water quality, there is no direct verification of its findings in previous work. There is also no way, within the confines of the study, to absolutely ensure that the reported levels of metals (or the levels of any of the other constituents) were valid indications of water supply contamination, nor to prove they were artifacts induced in some way by the study itself. On the other hand, since no previous study has looked as extensively at individual home supplies, intermediate systems, and small community systems, this study may have been the first opportunity to view the extent of water quality problems. But, rather than conclusively proving the status of rural water quality, the study strongly suggests important avenues for concern, and stands as a guide to further work.

Table 1

Constituents Measured in NSA Survey

Category	Constituent	Has Primary (P), Secondary (S), or No (N) MCL	Measured in All NSA Household Samples or only In Group II Subsample
Microbial	Total coliform	P	All
	Fecal coliform	N	All
	Fecal *streptococcus*	N	All
	Standard plate count	N	All
	Fecal coliform/fecal streptococcus ratio	N	All
Physical and Chemical	Turbidity	P	All
	Color	S	All
	Temperature	N	All
	Specific conductance	N	All
	Total dissolved solids (as determined from conductance)	S	All
	Hardness (as determined from calcium and magnesium)	N	All
Inorganic	Calcium	N	All
	Magnesium	N	All
	Nitrate-N	P	All
	Sulfates	S	All
	Iron	S	All
	Manganese	S	All
	Sodium	N	All
	Lead	P	All
	Arsenic	P	Subsample
	Selenium	P	Subsample
	Fluoride	P	Subsample
	Cadmium	P	Subsample
	Mercury	P	Subsample
	Chromium	P	Subsample
	Barium	P	Subsample
	Silver	P	Subsample
Organic	Endrin	P	Subsample
	Lindane	P	Subsample
	Methoxychlor	P	Subsample
	Toxaphene	P	Subsample
	2,4-D	P	Subsample
	2,4,5-TP	P	Subsample
Radioactive	Gross alpha	P	Subsample
	Gross beta	P	Subsample
	*Radium 226	P	
	*Radium 228	P	
	*Uranium	P	
	*Stontium-89	P	
	*Strontium-90	P	
	*Cesium-134	P	
	*Tritium	P	
	*Iodine-131	P	

*Measured only if the laboratory analyst considered gross alpha or gross beta readings sufficient to warrant further investigation.

Among those contaminants which are covered by primary MCLs (because they are potential health hazards), total coliform emerged as the most prevalent problem, exceeding the reference value in 28.9 percent of all rural households. Among constituents which tend to be aesthetically objectionable or impose economic costs (e.g., degrading to plumbing, laundry, etc.), iron was the most common.

The presence of total coliform organisms was the most common single problem and received the greatest attention in the analysis. Coliform organisms represent a problem in that they are used as indicators of the possible presence of pathogenic bacteria. The rate of total coliform presence in excess of one coliform per 100 milliliters of water (28.9 percent nationwide) was 15.5 percent among households served by community systems, and over 40 percent among those served by intermediate and individual systems (43.3 and 42.1 percent, respectively). Households served by systems with fewer than fifteen connections that were not wells (i.e., cisterns, springs, surface water, hauled, purchased bottled) had more than one coliform per 100 milliliters of water in 77.7 percent of cases. In general, households with low income (under $10,000) and low education (less than high school) were more commonly found to have coliform problems than other households. Poorly accessible and privately owned supplies tended to have coliform problems more often than other supplies. Households served by dug and bored wells, wells in which the water leaves the casing above ground level, wells with inadequate covers, inadequately maintained wells, and shallow wells all tended to have high coliform levels more commonly than those served by wells without those characteristics. Small systems, with few connections, repeatedly exceeded coliform levels more frequently than most large community systems.

Fecal coliforms were found among 12.2 percent of all rural households, but among only 4.5 percent of households using community water systems. Fecal coliform counts were above 200 organisms per 100 milliliters of water (a suggested upper limit in water used for swimming) for 1.6 percent of rural households.

Standard plate counts of more than 500 organisms per milliliter of water were encountered at 19.3 percent of households. In this case, the percentage of households with the problem, which used community water systems, was not dramatically lower than for those using intermediate and individual systems.

Turbidity was measured above one NTU among 16.5 percent of rural households. That rate varied from 23.8 percent in the North Central to 8.5 percent in the West. Households using community systems were least likely to have more than one NTU readings, 8.9 percent, compared to 24.0 percent for intermediate systems, and 24.7 percent for individual systems.

Color was measured above fifteen standard color units among only 2.3 percent of all rural households.

Total dissolved solids, estimated from specific conductance readings, was found above 500 milligrams per liter among 14.7 percent of all rural households. Households in the North Central and West were over that level 23.9 and 22.2 percent, respectively. The Northeast, on the other hand, had only 5.0 percent of households with levels above 500 milligrams per liter.

Magnesium was found above 125.0 milligrams per liter in only 0.1 percent of rural households.

Nitrate-N concentrations above 10.0 milligrams per liter occurred among 2.7 percent of households. Regionally, the proportion over that level was 0.3 percent in the Northeast, compared to 5.8 percent in the North Central.

Sulfates exceeded 250 milligrams per liter among only 4.0 percent of rural households, but households in the West and the North Central were over at rates of 11.7 percent and 7.4 percent, respectively. The Northeast and South had household supplies at that level in less than 1 percent of the cases.

Iron concentrations over 0.3 milligrams per liter were found in 18.7 percent of all rural households. North Central households exceeded that level among 28.2 percent of households, compared to 7.0 percent in the West. Households served by community water systems were over at the rate of 7.7 percent across the nation. By contrast, the percent of households with iron concentrations over 0.3 milligrams among intermediate and individual systems was 28.7 percent and 29.9 percent, respectively.

The pattern of manganese occurrence was very similar to iron. Households with more than 0.05 milligrams per liter occurred among 14.2 percent of the cases. The rate in the North Central was highest (19.9 percent); and lowest (4.7 percent) in the West. Households served by community systems were over that level at a rate of 7.2 percent, compared to 23.3 percent and 20.7 percent, respectively, among households served by intermediate and individual systems.

Sodium levels higher than 100 milligrams per liter appeared in 14.2 percent of rural households nationwide. That rate was as low as 6.0 percent in the Northeast, and as high as 19.2 percent in the North Central.

Lead was above 0.05 milligrams per liter at 16.6 percent of the households. The percent of households exceeding that level was lowest in the Northeast (9.6 percent) and highest in the South (23.1 percent). It was discovered subsequent to the data collection that a thin line of blue paint which marked the breakpoint on the glass ampules of nitric acid preservative contained cadmium and lead. It is likely that the average lead contamination due to the paint was 36 parts per billion (0.036 milligrams per liter). Assuming relatively constant contamination from the paint at that level, the estimated proportion of rural households over 0.05 milligrams dropped to 9.2 percent nationwide.

Arsenic levels in rural household water were encountered above 0.05 milligrams per liter in only 0.8 percent of all rural households. The preponderance of those households were found in small rural communities (population less than 1,000). Households in those communities were found with the high arsenic levels among 6.6 percent of the cases.

Selenium, nationwide, was found above 0.01 milligrams per liter among 13.7 percent of households. Most of that occurred in the North Central and West. Households in the Northeast and South had high rates in roughly 2 percent or fewer of the cases. In the North Central, that rate was much greater at 25.7 percent, but in the West a remarkable 41.3 percent of all rural households had more than 0.01 milligrams per liter of selenium.

Fluoride concentrations exceeded 1.4 milligrams per liter in only 2.5 percent of all rural households. The rate in the West, at 6.2 percent, was more than double the rate found in any of the other regions.

Cadmium was measured above 0.01 milligrams per liter among 16.8 percent of all rural households. Only 1.6 percent of rural households in the Northeast were over that level while 27.1 percent of those in the West were high. Households served by both community and intermediate systems had the high cadmium rates in more than 20 percent of the cases (21.2 percent and 26.9 percent, respectively) while 7.9 percent of the households with individual systems registered high. Here again, however, the paint on the acid preservative ampules apparently imparted some cadmium background to the readings. The average contamination was probably in the neighborhood of .92 parts per billion (0.00092 milligrams per liter). With that assumption, the national rate of high cadmium values dropped to 15.9 percent.

Mercury was found among 24.1 percent of all rural households to be in concentrations exceeding 0.002 milligrams per liter. That proportion climbed as high as 31.8 percent in the North Central, and dropped as low as 10.4 percent in the West.

Chromium was virtually nonexistent above concentrations of 0.05 milligrams per liter throughout the US.

Barium concentrations over 1.0 milligram per liter were rarely found (0.3 percent of all rural households).

Silver exceeded 0.05 milligrams per liter among 4.7 percent of all rural households. Among the types of systems serving rural America, community systems had the lowest rates (2.1 percent), and individual systems had the highest rates (7.1 percent).

Endrin, lindane, methoxychlor, toxaphene, 2,4-D, and 2,4,5-TP were virtually never detected among rural household water supplies.

Gross alpha radiation in excess of acceptable exposure occurred among 0.5 percent of rural households—predominantly in the South. Unacceptable gross beta radiation was never encountered in the survey.

While these findings are startling, they must be kept in perspective. The large percentages of rural households with high contamination levels was a function of the level chosen to represent "high"—in this case, the primary MCLs. Again, these levels should not be interpreted as the proportion of households with domestic water exceeding an MCL since no resampling for verification, as required for MCLs, was performed. The levels established as MCLs generally incorporate substantial safety margins. So, even though these levels were identified as "high," and they were higher than was generally expected, they should be evaluated concurrent with the fact that widespread water-related health problems were not apparent throughout the rural US.*

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*The Environmental Protection Agency has participated with other agencies on another national research effort on drinking water quality. The national Health and Nutrition Examination Survey (HANES I) has an augmentation survey of adults aged 25 to 74 years in the United States in 1974-1975. The HANES I study differed from the rural water survey in its purpose, in its statistical sampling plan, in the

Of course, the long term effects of waterborne contamination at currently encountered levels is not known. Even the relatively short-run impairment of health from what it would be without the ingestion of these substances is unclear. Rather than being clear indicators of possible health effects, these high percentages of households with water quality problems, especially coliform bacteria, reflected the marginality of rural water supplies against the backdrop of the primary MCLs mandated for community water systems.

In terms of general water quality, considering all constituents, households in the North Central had the poorest quality water followed by households in the West. Households in the Northeast tended to have the best water quality.

Households served by community systems tended to have the best overall water quality, followed closely by individual systems (usually wells), with those on intermediate systems generally having the poorest quality. Households in SMSA areas and those in large communities tended to have better quality water because they had higher proportions of households on community water systems.

WATER QUANTITY

Relatively few rural households across the US reported a shortage of domestic water. Perhaps because of the essential nature of water, most rural households have made arrangements for adequate quantity, on a regular basis, to satisfy most or all their needs. Moreover, the perception of occupants at most rural households was that their water supplies were ample: about 80 percent reported that the major household supply completely satisfied their water requirements, and another approximately 16 percent reported that it usually or almost always provided sufficient water.

Though most households had adequate quantities of water, a significant number did not. An estimated 700,000 households reported that their supply usually or always provided an insufficient quantity. Most often the insufficiency was attributable to deterioration or inadequate construction of the physical facilities. However, at the extreme, roughly 370,000 rural households hauled water from an off-premises supply, on a regular basis.

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water collection, in the water preservation, and in the laboratory analytical techniques. But some of the contaminants examined were the same. In general, the HANES I Augmentation Study results for metals showed lower concentrations than the rural water survey. Various inquiries into the differences have provided no satisfactory resolution.

The Augmentation Study Survey of adults aged 25 to 74 years in the United States of the national Health and Nutrition Examination Survey I (HANES I) is currently in preparation and will be published jointly by the National Center for Health Statistics and the National Heart, Lung, and Blood Institute.

Among households not connected to community systems, problems of insufficient quantity were more commonly experienced by those supplied by small systems (two through fourteen connections) than by those with their own individual system. Among households with their own supply, those with dug wells more frequently experienced insufficient quantity.

Among rural households connected to a community water system, the median daily household consumption was 664 liters (175 gallons). The median daily per capita consumption was 227 liters (60 gallons).

Consumption of domestic water was not uniform across the US. Western households had a consistently higher consumption pattern than rural households in other regions. No table differences occurred between households located inside and outside SMSAs, or among places of different size.

Among households connected to community systems, locational factors were less important in accounting for variability of consumption than: (1) unit cost (cost per 1,000 gallons); (2) number of people in the household; and (3) number of water-using devices in the household. Although of less importance, the affordability of water and type of ownership of the system were systematically related to variation in consumption. In general, the higher the unit cost, other things constant, the lower the consumption. As would be expected, the greater the number of occupants and the greater the number and usage of water-using devices (dishwashers, washing machines, swamp coolers, as well as toilets and bathing facilities), the greater the consumption. Likewise, the lower the ratio of cost of water to the household's total income, the larger the consumption. Somewhat unexpectedly, households connected to privately owned systems tended to consume approximately 50 percent more water than those connected to publicly owned systems, even after controlling for a number of other, potentially confounding factors.

AVAILABILITY

Most rural households had a readily available domestic water supply. Quantity referred to the usual amount of water. Availability, on the other hand, was defined, for purposes of this study, in terms of two components: (1) the supply's reliability, or uninterrupted service, and (2) the supply's accessibility—one which provided water, under sufficient pressure, when needed and for which the source was not at an inconvenient distance relative to the point-of-use by household occupants.

A total of 5.6 million rural households (roughly 26 percent) experienced water supply breakdowns during the year preceding the interview. Among those households, the majority experienced only one or two interruptions of service. About 15 percent of these households (3.2 million) indicated the breakdowns lasted more than six hours.

In terms of regional differences, household supplies in the South seemed to be somewhat less reliable than in the other regions. Although the reliability of SMSA and nonSMSA supplies was similar, there were differences according to the size of place classification. Generally, households in small rural communities reported supply breakdowns more frequently than households in large rural communities or other rural areas. Similarly, water supply breakdowns which were considered severe—lasting more than six hours—occurred more often among households situated in small rural communities.

Compared with households using individual or community systems, a larger proportion of households served by intermediate systems reported one or more supply breakdowns. In addition, a greater proportion of households served by intermediate systems reported breakdowns that were severe.

Regarding accessibility, sources were generally located at convenient distances from the household. Among rural households connected to community systems, connections involved only piping from the edge of the property to the house, generally a modest distance. Moreover, among households with their own, on-premises supply, over half were located within 10 meters (33 feet) of the house. However, comparatively greater distances were recorded at approximately 15 percent of the households—implying the need for more extensive piping or other mode of conveyance. For the approximately 370,000 households that had to haul water, accessibility imposed a far greater relative hardship.

Supplies were less accessible in the South and West than in the Northeast and North Central. Though accessibility of SMSA and nonSMSA supplies was similar, households located in open country were relatively less accessible than those located in villages.

COST AND AFFORDABILITY

The cost of water was not estimated for rural households using their own supply or for those connected to a system that didn't explicitly charge for water on a regular basis. Assessment of the cost of water was restricted to rural households served by community systems which had a billing system. Perceptions of cost, however, were assessed for all rural households.

Compared to many other consumable items in the US economy, water is inexpensive. The median household monthly cost per thousand gallons was $1.35 nationally. The median total monthly bill for water was $7.00. A ratio of billed cost to total household income (times 100), as a measure of affordability, indicated that three-quarters of all rural households were paying less than 1 percent of their income for water. Across the nation, water was found, at the extremes, to be as inexpensive as $.08 and as expensive as $23.41 per thousand gallons. Occupants in the majority of rural households (79 percent) felt the water was reasonably priced or inexpensive. Domestic water was perceived as expensive or very expensive at about 14 percent of households.

Costs of domestic water were not uniform across the US. Regionally the median cost per thousand gallons ranged from a high $2.00 in the West to $1.33 in the South. Households within SMSAs had lower water costs than those located outside SMSAs. The respective medians were $1.08 and $1.62. Median water costs varied only slightly according to the size of community in which the household was located.

Despite these findings, a greater proportion of rural households in both the South and West felt the water was expensive or very expensive. A greater proportion of residents living within SMSAs reported their water costs were high than was reported by those living outside SMSAs. Likewise, perceived costs tended to rise the larger the size of place.

In addition to locational differences, several other factors were found to be systematically related to household water costs. Regarding the amount billed monthly, the single most important factor was, as expected, the amount of water consumed. After adjusting for this factor, it was still discovered that total monthly costs increased with the number of household occupants, and the education level of the head of the house. Households connected to privately owned systems paid more than those connected to publicly owned systems. On the other hand, the longer the household had been connected to the system, the lower the total monthly cost.

It was found that lower unit costs (price per thousand gallons) were associated with (1) the size of the water system providing the water, (2) the system's source water, and (3) the amount of water consumed at the household. Generally, the larger the system, the lower the unit cost. Systems using ground water usually had lower unit costs, probably due to the lowered treatment and storage costs. Some price break resulted for households with large monthly consumption.

WATER SYSTEMS

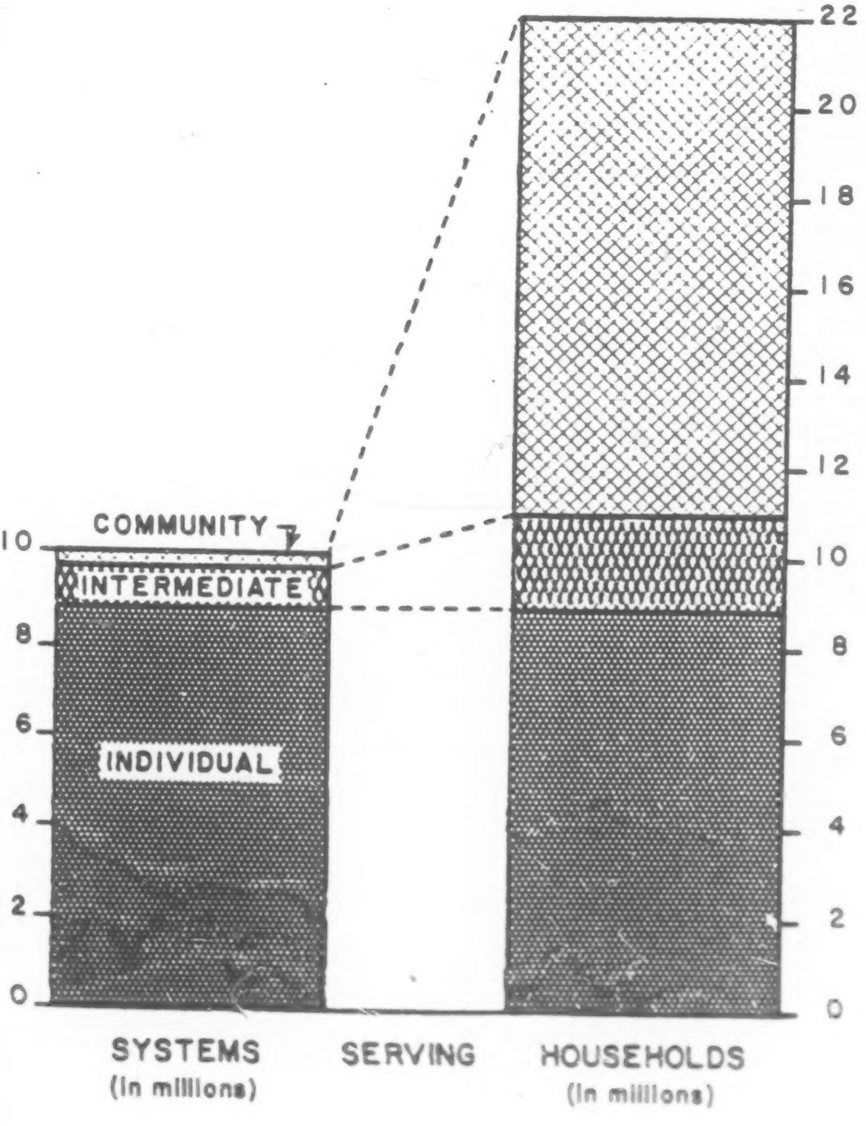
In this study, water systems were examined in order to specify technical, economic, and organizational features associated with delivering water to rural households. Rural water systems were classified according to three major system-size categories: individual systems (single connection), intermediate systems (two through fourteen connections), and community systems (fifteen or more connections). The community systems were further classified as independent (with self sufficient features) versus consolidated systems (with operating or organizational features integrated with other systems or administrative bodies).

Overall, individual systems were by far the most prevalent, numbering 8,765,000. In contrast, there were 845,000 intermediate systems and only 34,000 community systems. Because of this multiple-connection feature, however, intermediate systems and especially community systems were far more important in rural water delivery than implied by their numbers. When taking into account the number of rural households served by each type of system, community systems were most prominent (serving 10,981,000 households), followed by individual systems (serving 8,765,000 households), and intermediate systems (serving 2,228,000 households). See Figure 1.

Community water systems were defined for purposes of the study as those having fifteen or more connections. The standard EPA definition of public water systems is somewhat different. It refers to fifteen or more connection systems used by year-round residents or to systems which regularly provide service to 25 or more year-round residents. The NSA study's definition yielded a count of 34,000 community water systems. Had the study's definition been altered to ten or more

Figure 1

Comparison of Number of Systems and Numbers of Households Served in Rural America



connections, the count of community water systems serving rural America would have been about 47,200. The latter count is probably much closer to the standard EPA definition.

Individual Systems

Of the 8.8 million individual systems in rural America, 90 percent relied on wells. Other types of supply—surface water, springs, cisterns, hauled and purchased supplies—comprised the balance of individual systems across the country. These supplies were more often associated with poor quality water.

Nearly six of every ten individual wells were installed by drilling, which is one of the more highly recommended methods of installation because of the usually good contamination protection it offers. Dug or bored wells, which were often linked with bacterial contamination, represented nearly 18 percent of all individual wells. Individual wells were generally located 50 feet or more from most potential contamination sources, with the exception of sewage disposal systems. About one-fifth of all wells were within 50 feet of sewage disposal. Field inspection classified 62 percent of rural wells as appearing to have wellheads which were adequately sealed from solid or liquid pollutants.

Bacteriological tests and chemical (or physical) water tests by rural residents were not common. Slightly more than one-third of all rural households with individual systems had tested the water at least once, with bacteriological tests being more frequent than chemical tests. Test results, when they could be recalled, were generally classified broadly as "acceptable." But, nearly 45 percent of the bacteriological test results and nearly two-thirds of the chemical results were not known. This lack of knowledge may be attributable to the respondent's lapse of memory, poor filing practices, the length of time since the test was completed, or may have implied incomplete or uninterpretable reporting of test results.

Treatment practices can in many situations alter the quality of the source water provided to rural households. Among individual systems, the most common treatment device was a water softener (used in 18 percent of systems). Other water treating devices were rarely found.

Intermediate Systems

Intermediate systems were similar to individual systems. Over 90 percent had only two or three connections and less than 2 percent were metered. About 88 percent relied on wells, the majority of which were installed by percussion or rotary drilling (65 percent). Dug and bored wells comprised 17 percent of all intermediate systems wells.

Intermediate system wells were generally not located close to potential sources of contamination, except for roughly 16 percent which were within 50 feet of a sewage disposal system. Field inspection classified 67 percent of intermediate system wells as acceptably sealed against pollutants.

Water quality tests were performed less frequently among intermediate systems than individual systems. Bacteriological testing had been done at least once during the lifetime of the system at 22 percent of systems. Testing for chemical properties of the water had been done at 10 percent of systems. In contrast to individual systems, among those intermediate systems which tested, owners could usually provide information about the testing history as well as the test results. Of the bacteriological tests performed, over 91 percent showed acceptable counts of bacteriological content. As to treatment practices, among intermediate systems, softening—the most common treatment process—occurred in only 6 percent of the systems.

Information on average daily use and maximum daily (design) capacity collected at water systems provided some indication of the quantity of water provided to rural households connected to those systems. About one-third of intermediate systems had information on production and design capacity. Among those with readings, the median for average daily use was 758 liters, or about 200 gallons. The median design capacity was 44,000 liters (11,600 gallons). The median of the maximum daily design capacity was nearly 60 times the median "average daily usage" level among intermediate systems serving rural households. This difference suggests that some intermediate systems, similar to larger community systems, overbuild to a certain degree, allowing for expansion, fire protection, or increased consumption.

Availability indicators included the number and severity of system breakdowns, and the ease or difficulty in acquiring water from the source. About one-quarter of intermediate systems reported breakdowns of any kind, and few reported any difficulty obtaining water from ground or surface sources. The majority which did report breakdowns had experienced only one or two during an entire year. Despite these favorable findings, a very high proportion of households connected to intermediate systems reported reliability problems in the sense that nearly all breakdowns resulted in a loss of service to water users.

Most intermediate systems did not report revenues or any monetary charging structure for the water service they provided. This fact suggested that water was very cheap for intermediate system customers, but may have also indicated that system owners bear the entire cost of installation, operation and maintenance.

Independent Community Systems

Independent community systems were self-contained systems which secured water from their own sources, treated the water, distributed it, and managed their own organizational and financial affairs. They comprised about 88 percent of the 34,000 community systems in rural America.

Although independent community systems had more extensive extraction, treatment, and conveyance arrangements than intermediate systems, they still were very small in comparison to the larger, more complex systems such as those based in large cities. The median number of connections was 59 and the median length of distribution lines was 1.5 miles. About half of these systems metered their connections. Similar to smaller systems, the predominant source of water was ground water (90 percent). The labor-time demands involved in operation and maintenance of the system were modest, with many requiring two or fewer man-days of labor per month.

Water testing and treatment were much more frequent and extensive at independent community systems than at systems with fewer than fifteen connections. Fully 91 percent had conducted bacteriological tests and about 54 percent had done chemical testing. Treatment equipment was installed at nearly two-thirds of all independent systems. Most independent systems relied on facilities outside their own organizations for performing water quality tests. For the most part, bacteriological tests conducted during the year prior to the study (1977) reportedly met the levels prescribed by regulations affecting the systems. In general, there were too few chemical and physical tests performed to suggest meaningful patterns.

About 63 percent of independent community systems provided average daily usage and design capacity figures. Among those which reported, the median for average daily usage was 136,000 liters (36,000 gallons). The median design capacity was 546,000 liters (144,000 gallons). Maximum daily production capacities among independent systems were four times larger, on the average, than the estimated average daily use. Though this ratio was less than for intermediate systems, it was large enough to accommodate fire protection, increased usage, and increasing the number of connections because of the larger volume being produced daily.

Independent community systems were less reliable than intermediate systems. A larger proportion of independent systems (55 percent, compared to 26 percent) had breakdowns, although fewer resulted in an interruption of service to customers. As was true for intermediate systems, few had difficulties in obtaining water from any source.

Consolidated Community Systems

The consolidated community systems relied on interdependent links with other organizations. One type of consolidated system had a number of separate, individual facilities of which each served one community, but which were jointly owned and administered by a central company. Another type consisted of a facility which purchased water from another organization—a situation which was the distinguishing feature at nearly 90 percent of the consolidated systems.

The consolidated systems tended to be the largest of the systems serving rural America. The median number of connections for the 4,000 consolidated systems was about 153—two and one-half times the median number for independent community systems. Likewise, consolidated systems employed more system operators and metered a larger proportion of all connections.

Testing for water quality was more extensive at consolidated community systems than at independent community systems. Bacteriological testing was done at almost all (98 percent) consolidated systems, and chemical testing was performed at about 90 percent of systems. Results for bacteriological tests were not uniformly interpretable. But, about 96 percent of the systems reporting tests had acceptable results for either the previous twelve tests or for those tests conducted over the last year. The variety of constituents tested, disparities in the age of the tests, and the lack of information on analytic procedures combined to render the chemical testing results uninterpretable.

Similar to independent community systems, consolidated community systems could produce, on the average, over four times the quantity of water that was consumed on a daily basis. The median for average daily use was 162,000 liters (43,000 gallons) among the 88 percent of consolidated systems which had the information. Design capacity was obtained for half of the consolidated systems. The median design capacity was 719,000 liters (190,000 gallons).

About 50 percent of consolidated systems had breakdowns during the year preceding the study. This proportion was slightly smaller than for independent systems (55 percent), but still considerably greater than for intermediate systems (26 percent). This finding could be interpreted to mean that problems of reliability were more often associated with larger, more complex systems. However, it was also the case that these larger systems more frequently had alternatives in the event of some malfunctions (such as auxiliary pumps, storage capacity sufficient to cover demand during a breakdown, and so forth).

CONCLUSIONS

1. Most rural households had a domestic water supply which was acceptable by most of the quality indicators used, was in sufficient quantity to meet consumption demands, was readily available on a continuous basis, had a reasonable cost, and was affordable. But, the exceptions were not rare and the difficulties were not always minor.

2. The overwhelming majority of rural households had water judged to be of acceptable quality for any particular characteristic studied. But, almost two-thirds of all rural households had water judged unacceptable for at least one of the constituents which have been given primary MCLs (excluding turbidity). Bacterial contamination, in particular, was the predominant problem encountered.

3. The quality of the water available in most rural households was due to numerous factors, but a few can be highlighted. Most rural households (on the order of 90 percent) relied on ground water. High quality well technology and well construction practices were generally evident throughout rural America. Their employment apparently helped minimize alteration of the water from the quality it had at the source until it was delivered to the tap.

4. Larger, more frequently monitored community water systems generally delivered water of higher quality than smaller and less frequently monitored systems.

5. By comparison with community systems, individual and intermediate systems employed less complex technologies and less frequently used water treatment devices. Therefore the quality of the water delivered to the household was mainly a reflection of the quality of the source water (which was ground water for 90 percent of these systems). As long as the fundamental quality of the ground water source remains intact, further improvements in well technology and construction practices would beneficially affect the quality of delivered water by ensuring the protection of the quality from source to tap. A larger benefit would probably result from presently deficient wells being replaced or brought up to current standards of good practice for well construction. Direct regulation of small (usually individual) water systems would probably not dramatically alter water quality because of the common lack of treatment devices and the improbability of their installation due to the relatively large capital costs for the individuals involved.

Therefore, perhaps the greatest protection for the continuing quality of water from noncommunity water systems would be the preservation of ground water quality, particularly the freedom from bacterial contamination. Acceptable well construction practices for households using individual and intermediate wells appeared to reduce bacterial contamination potential. Proper siting of wastewater disposal, or wastewater removal by public sewer systems were also associated with lower bacterial contamination for households served by individual systems. Additional improvement in water quality among water systems with fewer than fifteen connections might result from wider availability of water testing services and public education on their availability, their importance, and on possible response alternatives to identified problems.

6. The more extreme the rural householder's evaluation of the water supply, whether good or bad, the better was the correspondence with the composite indicators of laboratory-measured quality. Households which were very positive about their supply usually rated well on the laboratory measures. Households in which the water supply was given a poor rating also tended to have laboratory-measured deficiencies.

Responses to questions regarding the relative cost of the supply and the respondent's willingness to pay more for an improved supply were both useful indicators of the quality as measured by the laboratories. In general, households reporting low relative costs or strong willingness to pay more for an improved supply, tended to have poor water quality according to composites of laboratory measures. Households which reported their supply was expensive or where the respondents lacked a willingness to pay more for an improved supply tended to have superior quality water according to the laboratory indicators.

7. It was noted that average daily consumption of water was greatest in the West. This was so even though the unit cost of water was highest in the West. Rural households of the West generally relied upon their major household supply—usually a community water system—for virtually every water need around the home, yard, and garden.

Over the last fifty years or so, there has been a federal subsidization of Western water through low interest construction loans on large scale reclamation projects. Water cost comparisons among large Northeastern cities and large Western cities have frequently resulted in the observation that Western cities often charged far less for domestic water than those in the Northeast. That effect was not borne out by the NSA for systems serving rural Westerners. Most of the community water systems in the West were relatively small and they were charging on the average the highest rates among systems serving rural America. (Possibly, there is an important economy of scale related to the acquisition and transport of the water. Large systems are more likely to be primary customers, that is, to have a direct arrangement in terms of payment and piping with large scale reclamation projects. Smaller systems, on the other hand, may end up being secondary customers which buy from large systems at some higher price. But even when a small system obtains its water directly from a large scale reclamation project, or from a smaller local project, or from a deep well, the relative cost per connection would generally be higher than that experienced by large systems. Thus, even with the federal subsidization of much of the developed water in the West, the average unit cost for water among rural Western households was higher than for other rural parts of the country.)

8. Intermediate systems were found to provide generally inferior service compared to community and individual systems. It is suspected the reasons for this lay with the nature of the design.

Apparently most of these small systems were not originally designed or intended to be integrated, multiple-connection systems, but were originally installed as individual systems to which additional households were later connected. For instance, a relative, hired hand, or friend could build a home adjacent to a house with an existing individual supply. Because of the cost of installing a new system, occupants of the new household might ask, or be invited, to hook up to the existing well rather than install a separate facility. It appeared that many small intermediate systems seem to have started as individual systems and evolved to become two and three connection systems without any accompanying redesign. Many of these extended connections were probably homeowner installed.

The result of these extensions and modifications to the original system is a strain on the capacity of the system. These apparently stressed systems provided, as a group, the poorest overall service of any system configuration studied. A higher proportion of households connected to intermediate systems experienced problems with water quality, they more frequently had insufficient quantity, and they tended to report a greater number of breakdowns.

The trend in many parts of the country toward falling ground water levels and increasing well construction costs may increase the likelihood of more rural households entering into multiple connection arrangements on individual systems not designed for that purpose.

* * *

This executive summary captures in only the broadest form the detail of the full, 1,900 page, report. The five volume document describes attributes of rural water users, households, supplies, and systems as they related to the quality, quantity, availability, and cost of rural domestic water conditions. Each topic is explored for the nation as well as for various subnational categorizations. The study is a one-time effort which strives to be comprehensive, rather than exhaustive on any particular topic. The report is the first systematic, nationally representative examination of the broad issues related to rural domestic water.

8 What Must Change

The man that makes character makes foes.
E. Young

Aside from the obvious economic and political problems, large-scale technological/structural approaches to water supply crises ignore a major constraint fundamental to a real, permanent solution to our nation's water problems. No water redistribution scheme, however expensive or well conceived, can create more available water; it can only redistribute extant supplies from regions of relative abundance to relative scarcity. There is no question that the heightened availability of water in a hitherto parched region would infuse that region with a degree of heightened productivity. There is also no question about the fact that these benefits would only accrue in the short term. Inevitably, the newly available water would be used to fuel a new round of demophoric growth which would quickly absorb temporary surpluses and lead to a new round of water crises.[1] The severity of this future water crisis would dwarf our current situation, because the overexpanded steady-state economy fostered by the rapid infusion of water could not be sustained without massive water subsidies, which would largely cease to exist. We must realize that ***there are finite limits to the amount of water which can be extracted from a given environment and that no technology can increase this extractive capacity indefinitely.*** These ultimate limits are dictated by events in the hydrological cycle which are beyond man's control. Despite allegations to the contrary, we can do little to increase the amount of precipitation falling on the North American continent, and this would be the only process by which the ***absolute*** rate of water recharge could be affected. There is, in fact, evidence which suggests that the absolute resupply rate may diminish in coming years due to general climatic drying. However, there is much we can do to maximize the processes which operate in nature to convert rainfall

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to long-term water storage, and thereby affect the *realized* rate of water recharge.

It is in this vein that meaningful, long-term solutions to our current water crises must develop. We must learn to use water to its maximum potential and foster policies, whenever possible and at all levels of society, which maximize rather than deter the operation of the hydrological cycle. This ethic is beginning to become part of official government policy and must become universally accepted if we are to permanently effect real change.[2]

There are many things we as individuals and as a society can do to ensure a stable transition into what will almost surely be a water-limited future America. We must recognize the fragility and real economic value of the natural processes which supply us with usable water. This "real value" economic view must permeate all water-based industrial, agricultural, and residential practices. Almost every human activity is predicated on the availability of water. This real value is incorporated into every product we produce and use. Any change in policy which requires capital outlay to initiate must reflect this real water cost. Ultimately, these costs must be borne by the consumer. As we directly or indirectly subsidize energy conservation and the development of alternate energy sources, so too must real water costs be reckoned with. In the long run, the notion that water has real economic value will do much to forestall wasteful practices, on both an individual and a collective level. Efficient use and intensive recycling will not cost more in the long run. Rather, the costs will be less, because as fresh water becomes limiting, costs will increase exponentially until excessive use is prohibitive.

By purely voluntary means, without sacrificing individual freedoms or real economic growth, we still can dictate our own water future. Literally, the only factor in the water consumption equation which we cannot change is essential physiological need. We have seen that this amount of water usage is trivial. The thousands of gallons of water used per capita per day by other processes are directly addressable and amenable to change. All changes we propose here not only make good environmental sense, but are also economically beneficial in the real sense of the word. They are predicated as the belief that water is a precious, limiting resource with definite intrinsic value and that this value will increase in the years ahead. Many of these changes sound trivial: they are not. Massive per capita reductions in water usage and environmental constraints which maximize water recharge will occur only through the combined efforts, large and small, of all levels of society.

Residential Changes

Most residential water systems are designed for highly inefficient water use. An average family of four uses approximately 233 gallons of water each day, with 74 percent of that usage occurring in the bathroom.[3] Toilets consume more water than any other fixture in the home, an estimated 40 percent of all water used indoors. Older toilets use 5 to 7 gallons of water per flush. New low-flush toilets or modifications of older models reduce this usage to about 3½ gallons. Technology already exists to adequately flush toilets with less than ½ gallon of water.

Bathing accounts for 34 percent of water used in the home, with about 60 percent of this total used in the shower. Conventional showers use up to 10 gallons per minute. Water use in showers can be reduced up to 70 percent by the installation of inexpensive and readily available water-saving shower heads.

Major kitchen appliances, such as automatic dishwashers and garbage disposals, can be notoriously water-inefficient. Older dishwasher models consume 13 to 16 gallons per cycle; newer water-saving models consume only half as much water per cycle. Water used in hand-washing of dishes can be halved simply through the addition of modified faucets in the kitchen sink.

Other water conservation methods in the home are manifold. These include clothes and dish washing using only full loads, taking shorter showers, using less bath water, and reducing the use of garbage disposals. Outdoors, especially in urban areas, careful discretion in lawn watering can save enormous quantities of water and decrease the runoff of nutrients and pollutants from lawns to stream and groundwater systems. Heavier, less frequent watering during the coolest part of the day minimizes evapotranspiration losses and encourages the development of healthy, deep-rooted grass plants.

We already encourage water conservation in many parts of the country during periodic drought conditions. The general application of water-efficient practices by individuals in the home would go a long way toward alleviating chronic water shortfalls certain to occur in future

United States society. Although residential water use constitutes a relatively minor proportion of total per capita consumption, home water conservation is an important step in changing public attitudes about the preciousness of water. When these attitudes become ingrained, other conservative practices in society as a whole will be more easily accepted. We have seen this pattern already with regard to home energy conservation, and, as in energy limitations, realistic pricing strategies for residential water use may force more stringent residential water conservation.

Water used for residential waste removal is still relatively uncontaminated. To use five gallons of water to dilute one pint of urine is patently absurd. This water can be purified and recycled within the home by systems already developed and on the market. Further, the whole problem of wastewater can be eliminated through waterless sanitary systems currently on the market. In many areas, these systems are presently banned by archaic attitudes and statutes. These laws should be rescinded. To be sure, retrofitting homes for water efficiency, just as for energy efficiency, costs money. Residential tax credits, similar to those extant for energy conservation devices and retrofitting, should be adopted, both on the state and federal levels. In new home construction, a water-efficient system is presently only slightly more expensive than a standard system, and the homeowner would certainly recoup his added investment rapidly as water costs rise precipitously. Further, onsite treatment of wastes and reducing residential water usage put less of a burden on strained municipal water and sewage systems. The need to build more of these expensive facilities would be markedly reduced by individual residential efficiency.

A General Accounting Office (GAO) study (1982) examined the reliability and cost-effectiveness of the sixty-five thousand municipal water delivery systems in the United States and uncovered some shocking statistics.[4] A total of 43 percent of our nation's water delivery systems failed to meet current EPA standards for water purity. While the safety record of the municipal water industry has been remarkably good, 22 deaths and 407 disease outbreaks were directly attributable to unclean drinking water in the period from 1961 to 1978. The GAO estimated that perhaps ten times as many cases were unreported during that same time period.

Additionally, the GAO found that 40 percent of communities surveyed were not charging users enough to cover the costs of delivering water, intending for federal monies to make up shortfalls. Under the present economy realities of federal and state governments, it is unlikely that such pricing strategies will go unchallenged. It is clear that the real costs for residential water use must be reflected in water bills. In a study on residential water use in Tucson during the 1970s, data indicated that higher prices for peak water usage and not appeals for voluntary conservation were the main causal factors for declines in water consumption. In an age where water rights are worth more than land itself in some parts of the U.S. (Colorado is an example) and where water-based mutual funds are seriously being considered, pricing strategies must clearly indicate to consumers that water they use indiscriminantly is dearly bought and precious. New residential construction must also be completed with a realization that water planning is at least as important as energy efficiency.

There is evidence that such planning can work and is economically justified. An ecologically planned community (The Woodlands, Texas) has adopted a unique water management plan designed to avoid adverse water quality effects due to urbanization while maximizing natural existing drainage patterns. An extensive scientific study on this community has documented the plausibility and desirability of such approaches.[5] In addition to wide use of natural buffer areas in construction, this community experimented with a new kind of porous pavement which would permit water infiltration rather than promote runoff of storm waters from nonporous paved surfaces.

Protection of Natural Water Sources

We have emphasized the interrelated nature of groundwater and surface water sources. We have also shown how the hydrological cycle includes a complex web of interactions between terrestrial and aquatic ecosystems. It should be clear by now that the protection of water sources from contamination or excessive water drawdown is an important facet in preserving such sources for continued use by man.[6]

The Safe Drinking Water Act of 1974 recognized the importance of source protection in maintaining and enhancing not only drinking water quality but also the actual supply of usable water for other purposes. Because pollutants rapidly become dispersed in the environment (see chap. 2), it is economically more efficient to keep water sources as pure as possible, so that treatment of water from these sources can produce safe water at reasonable costs.

In chapters 2 and 4, we saw how groundwater and surface water sources become contaminated by toxic wastes, runoff pollutants, and hazardous materials. Erosion and sedimentation, contamination of the atmosphere, and other processes also directly affect the integrity of usable water sources.

The protection of water sources in future America need not resemble the doctrine of protectionism which influenced U.S. environmental policy earlier in its history (see chap. 5). Cognizant of the demands of economic growth and increasing urbanization, a policy of isolation of natural resources is untenable.

Rather, as a nation, we have begun to see the immense economic and health problems which accrue to an entire region when one private company, municipality, or other social unit indiscriminately pollutes a common water source. Legislation to combat the illegal dumping of toxic wastes, the unauthorized use of herbicides, pesticides, and other contaminants within watersheds, the indiscriminant dumping of untreated sludges, and similar violations, already exist. In no case should government agencies become lax in enforcing these laws or rescind them under the guise of economic freedom.

Several "principles of protection" summarize these views:

1. The contamination, pollution, and any degradation of the quality of water supply sources have damaging effects on health, well-being, *and economy,* as well as on the general environment.
2. Physical laws dictate that dispersed pollutants are *always* more expensive and difficult to clean up. From an economic standpoint, cleanup efforts must be directed as close to the source of contamination as possible.
3. The responsibility for preventing and abating pollution or contamination of water sources rests with those who discharge noxious materials, directly or indirectly, into water sources, the land environment, or the atmosphere.
4. Because water problems are generally regional in nature, all levels of government and industry must coordinate and accept the responsibility for water source protection.

5. Land, water, and air are interrelated resources. Planning, management, and use of these common resources must consider their mutual influences and impacts in an integrated manner.[7]

We spoke earlier about the usefulness of natural buffer areas to increase water recharge rates, decrease erosion, and ameliorate the effects of waterborne pollutants. The protection of water sources must include inland wetland areas. There are many concrete examples linking the degradation of wetlands to the disruption of other water sources. The Everglades of Florida, which represents a vast network of wetlands, is essential not only for the preservation of countless plant and animal species, but also to the water economy of the state of Florida.

While the vast size of the Everglades makes it a particularly graphic example of these processes, similar effects can be noted in most marsh habitats. For example, one of the major problems associated with reservoir impoundments, particularly in regions like Tennessee, the plains, and the Southwest where erosional loss of soils is high, is that sedimentation processes rapidly fill the newly constructed reservoirs with silt, fouling the waters and reducing the useful life of the reservoir. Thus, a body of water with a projected life of perhaps a hundred years must be dredged every few years at great expense or else will fill within decades. Researchers have demonstrated that the lack of marsh vegetation surrounding the margin of many of these systems is an important contribution to high sedimentation rates.[8] The marsh habitat stabilizes soils which would otherwise wash into the water body. In an age where new construction of reservoir systems is becoming increasingly expensive, the economic benefits of so simple a strategy as wetland protection readily becomes apparent.

Agricultural Water Use and Degradation

Agricultural water use exceeds nearly every other component of the water utilization equation. Poor agricultural techniques contribute large quantities of pollutants to surface water systems and reduce the percolation of rainfall so necessary to groundwater recharge. The projected increased demand for food makes it imperative that irrigation water conservation and wise land use practices supplant currently prevalent methods.

It is clear that massive supplies of cheap irrigation water may cease to exist in much of the United States. Further, intensive irrigation and resultant salination of once fertile soils has become an expensive and increasingly alarming problem. We presently have the technological capacity to address these problems. The time has come to implement these changes.

Farmers are increasingly moving away from wasteful irrigation processes, but this trend must become more widespread. Since 85 percent of the freshwater demand on a world level is consumed by agricultural irrigation, conservation in this area has enormous economic and environmental impact. We know that most irrigation water is wasted through improper or excessive application. It is against this background that trickle or drip irrigation is gaining increasing acceptance. Drip irrigation, in which the crop, not the soil, is irrigated, has been in use for nearly fifty years, but has only recently become widely applied. In drip irrigation, water is applied slowly and uniformly to a crop at or below soil level and adjacent to the plant by means of mechanical water outlets.

Water uptake by plants is more efficient and far less soil water is lost through evaporation as compared to conventional methods like center-pivot irrigation. In arid regions such as Israel, nearly all irrigated land is moistened by the drip method. Recently, California, Texas, Florida, Arizona, Michigan, and Hawaii have begun to supplant older methods with modified drip irrigation techniques. In Israel, water for irrigation is used with 85 to 90 percent efficiency compared with only 35 to 40 percent efficiency for the United States as a whole.[9]

In addition to actual water savings, drip irrigation has many other economic benefits. Labor and energy costs for pumping are reduced greatly, so much so that the typical drip system can often pay for itself within one year of operation. Weed growth is retarded since only the areas immediately adjacent to the crop are watered. Drip irrigation can use water of higher salinity than conventional techniques. In the drip method, accumulated salts are pushed to the periphery of the wetted soil by the advancing front of water. Since the total water added to the soil is much less than with conventional methods, the overall salination of the soil is similarly reduced.

Problems in drip irrigation do exist. There is a tendency for soils to become salinized over a long period of time unless a small amount of deep percolation is allowed from time to time to leach salts below the rooting zone. Water must be filtered prior to application so that the emitters are not clogged by particles. In marginal agricultural areas, however, more crop yield can be grown on far less water and for far less money than by any conventional technique.

Trickle or drip irrigation is by no means the only way to reduce our vast irrigation water subsidies without harming crop yields. If we look at the 97 million acre-feet of water consumed by irrigated agriculture on an annual basis in the United States (1975 figures), the potential for massive water savings immediately becomes evident. In 1979, a governmental interagency report by the Departments of the Interior and Agriculture and the U.S. Environmental Protection Agency determined that additional public and private investment of up to $5 billion over the next three decades directed at water conservation in irrigated agriculture could decrease gross annual diversions of irrigation water by 15 to 20 million acre-feet *using existing technology.*[10]

What are some of these suggested strategies? First, we must realize that any irrigational strategy must be tailored to local and regional conditions. The regional diversity of climatic regimes, soil conditions, and water demands in the United States is vast. The irrigation needs, economies, and water resources of each region of the country differ greatly. We have seen that the heterogeneous nature of water supply and demand in the continental United States creates many problems for resource planners. Nonetheless, regional similarities in irrigation requirements do exist, and allow planners to simplify strategies somewhat.

The continental United States can be conveniently segregated into a series of irrigation characterization areas based on regional similarities in annual rainfall and runoff, topography, soil conditions, crops, and other factors (fig. 3). We have already discussed some of these regional similarities in earlier treatments of freshwater dynamics and regional water crises. Despite small local differences, growers in a given area, e.g., the southwestern region, can be expected to encounter similar irrigational needs and problems and would benefit by similar strategies to meet these needs. In spite of the diverse nature of these regions, certain conservative practices have universal appeal. In the next section, we will discuss the enormous savings of water which would accrue from more general use of wastewater effluents in irrigation. For now, we will look at strategies designed to increase the efficiency of water delivery to crops, from wherever that water comes. Such strategies become pro-

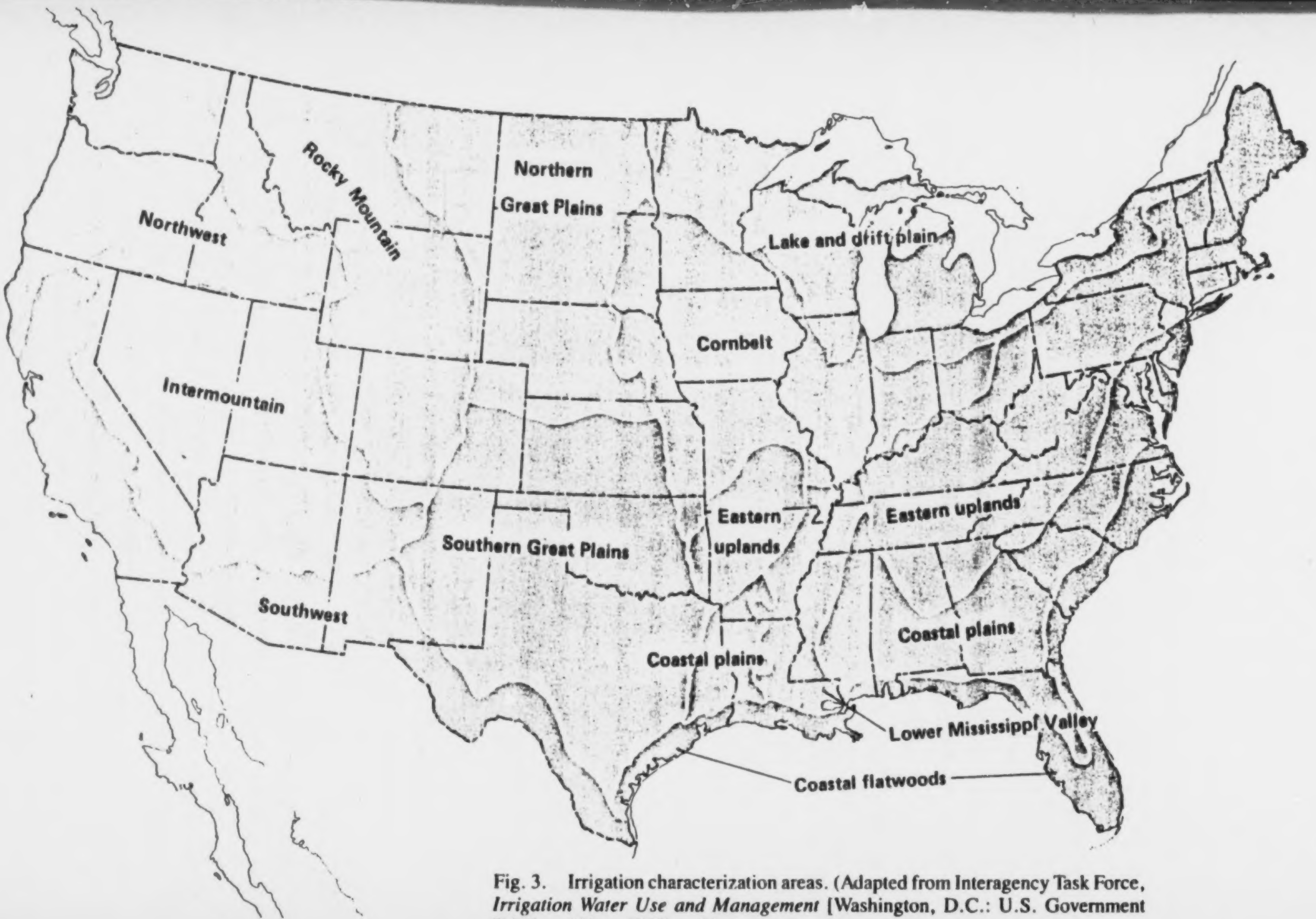


Fig. 3. Irrigation characterization areas. (Adapted from Interagency Task Force, *Irrigation Water Use and Management* [Washington, D.C.: U.S. Government Printing Office, 1979], p. 28.)

gressively more important in regions like the western half of the United States, where water is chronically scarce.

One major way to save water in irrigation is to line irrigation channels and laterals with impermeable materials like concrete or flexible plastic. Lining a conveyance system reduces seepage of valuable water by approximately 75 to 90 percent. Other benefits of lining delivery channels include (1) the control of ditchback weeds and aquatic plants which consume water, (2) a reduction in soil erosion, (3) an improvement in water quality, (4) a reduction in operation and maintenance costs, (5) reduced drainage requirements, and (6) reclamation of agricultural lands lost to seepage. There are, of course, certain drawbacks to lined conveyance systems. They may reduce vegetation and open water habitats used by wildlife and may reduce percolation of water to shallow groundwater reserves.

Piped conveyance systems, generally used to date only in mountainous areas, can increase water delivery efficiencies to greater than 95 percent. In addition, piped systems lose little or no water to evaporation, a major consideration in overall water efficiency.

In each of the above systems, planners have reinforced the need for more stringent control over the rate and timing of water deliveries to irrigators. In the past, unregulated delivery of irrigation water often led to waste and excessive wetting of field crops. A recent federal program has outlined guidelines for water deliveries within local distributional systems that would not only save water but also might lessen the need for construction enlargements of existing delivery systems.

Once water is delivered to the farm, much can be done to ensure its wise use. Field testing of water control structures, land leveling systems, flow measurement devices, and tailwater recovery systems have demonstrated that great water savings are possible on most irrigated land with minimal capital expenditure. For example, while drip irrigation may be impractical for small grain crops such as wheat or sorghum, farmers can easily adapt furrow or sprinkler systems for heightened efficiency. Research has shown that with wheat and sorghum, water can be applied in furrows as far as 160 inches apart (as opposed to the 40-inch furrows normally used) without loss of crop yield.[11] Such wide-furrow irrigation can also be used with center-pivot systems, using drop tubes in the pivot arms instead of sprayers. In effect, more water is made available for plant use; less is wasted to evaporation, percolation, and runoff.

Clearly, the farmer needs help in understanding and applying the complexities of efficient water management to his own situation. The Department of Interior's Bureau of Reclamation provides an Irrigation Management Services program to districts associated with reclamation projects. Several universities, state agencies, irrigation organizations, and numerous private firms provide similar services in planning assistance. Statistics on such programs indicate that 20 percent increases in water use efficiency are easily obtainable. So far such programs have only been applied on about 1 million of the 50 million acres of irrigated farmland in the United States (1977 figures); clearly, much remains to be done.[12]

In the current economic climate of high interest rates and low crop prices, the farmer must not only be convinced that water use efficiency will help him, but he must also receive some sort of governmental help to achieve such goals. There are numerous economic benefits and incentives to improving irrigation efficiency, especially in water-poor regions of the West. As we have noted, reduction in labor requirements, better utilization of fertilizers, energy savings, and higher crop productions all put more money in the pocket of the farmer who improves the efficiency of his irrigation strategy.

To help farmers in this area, most states now have several programs aimed at fostering agricultural water conservation. Because states are generally responsible for administering water laws, water rights, and regulatory programs and because state universities, especially land grant institutions, are heavily committed to agricultural research, such programs can be very useful. Aside from planning assistance, many states have substantial funds available for grant or loan programs, primarily involving construction loan funds which are available at reduced interest rates. Many such programs also use federal dollars and all are designed to improve the efficiency of outdated irrigation systems. It is encouraging that, even in hard economic times, most states are currently expanding, rather than cutting back, funding levels to water programs. This expansion must be accelerated.

Federal programs for irrigation assistance, which began with the passage of the Reclamation Act of 1902, remain a major source of direction in the effort toward agricultural water conservation. Some thirty-five federal programs involving about ten separate agencies are currently involved in irrigation assistance, and in recent years funding levels have exceeded $175 million annually. However, with recent cuts in the budgets of such agencies as the Environmental Protection Agency and with the recent presidential thrust toward a "New Federalism," the federal government cannot be counted on to shoulder the major portion of the burden for water development funding.

Many observers and analysts believe that the private sector is more than capable of picking up the slack in this regard. It is estimated that in 1977, private annual investment in irrigational improvements exceeded $710 million.[13] It seems clear from past experience that federal/state/local/private cost-sharing strategies will offer real benefits to government, individual farmers, and private investors in the decades ahead.

Improvements in irrigation methods are not the only water-saving measures which can be adopted. Most agricultural fields are currently planted in row upon row of monospecific stands. Maintaining an artificial monoculture requires proportionately greater energy and water inputs than growing multiple crops on the same site. Whenever possible, multiple crop planting should supplant monoculture agriculture, particularly in marginal farming areas. Water losses in marginal semiarid areas can also be minimized through plant enclosure techniques, which are particularly useful for vegetable crops.

Much agricultural irrigation water is drawn from groundwater aquifers, even in parts of the country, such as the plains, where groundwater reserves are already overburdened. Pumping water from deep within the earth requires much more energy than is required to pump surface waters. In the interests of both energy and water conservation, surface waters should be used whenever possible for irrigation, thus reserving the frequently higher quality groundwaters for more direct human needs.

The increased development of salt-tolerant plants, so-called halophytes, is another important step in making irrigation water go further and preserving higher grade water for direct human use.[14] The possibilities are tantalizing. Every year, another half-million acres of farmland worldwide become too salty for conventional farming because of saline accretions resulting from evaporating irrigation water. Specifically, 12.7 percent of the agricultural real estate in California and up to one-fourth of the land within the lower Rio Grande Valley have serious salinity problems. While saline soils and irrigation water are incompatible with normal crop growth, halophytes can be cultivated with brackish water containing salinities of over 3,000 parts per million (roughly one-tenth the salinity of ocean water). Approximately one-tenth of the total North American land mass lies directly over reachable, brackish aquifers within this salinity range which could be used in halophyte or drought-resistant plant agriculture. In all, it is believed that the United States has ready access to more than 18.5 billion acre-feet of readily pumpable saline groundwater, including roughly 3 billion acre-feet (roughly the volume of Lake Michigan) in the critically water-short mountainous West.

The general use of high-yield "Green Revolution" strains, which produce high yields only with massive water and energy subsidies, has prevented the widespread development and utilization of drought-resistant and salt-tolerant plant cultures, because until recently, these water and energy subsidies have been available at reasonable cost. As water and energy diminish in availability, we must be ready to replace water-dependent crops with other strains or face agricultural chaos. To this end, research aimed at developing alternate crop strains must intensify and agricultural water subsidy practices, which grant depletion allowances to excessive users of irrigation water, must be phased out. The latter practice only acts to forestall the necessary change to less water-intensive farming practices more in line with economic and environmental realities.

Wastewater Reuse

The American propensity for cleanliness has led to great benefits by reducing disease and permitting diversion of our energies to other activities. That cleanliness can be misconstrued and detrimental if carried to the extreme. The repulsion of many to human waste products is an immature attitude—we must enter a recycling society, and the nutrients of human origin cannot be wasted. The waste products can easily be rendered safe from communicable diseases and are no different from the wastes of other animals. Despite superior intellect, humans are still functionally animals!

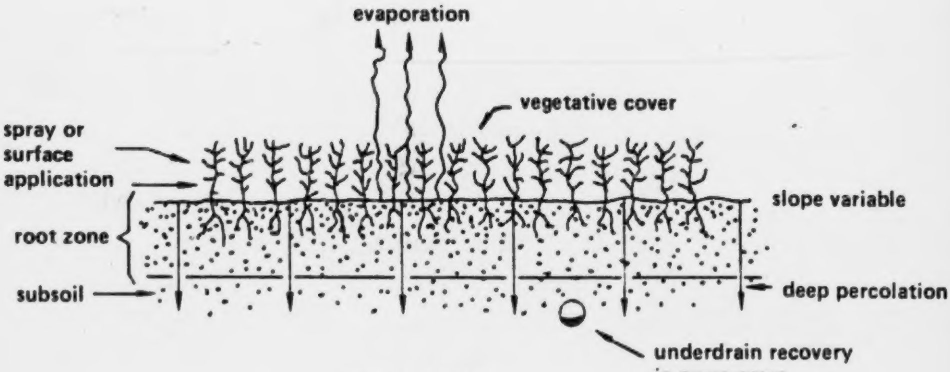
Human sewage, rich in valuable plant nutrients, can be pumped directly onto fields with minimal treatment, in effect recycling both water and nutrients. The erroneous idea that this practice is somehow unsanitary must be replaced with an appreciation for the beneficial overall effects of sewage utilization. We can no longer afford to waste either fertilizer, energy, or water in agriculture. It may take a massive informational campaign for such recycling techniques to become acceptable, but the beneficial effects would be well worth it.

According to governmental statistics, more than 50 percent of the wastewater sludges produced by municipalities are disposed of on land.[15] The potential value of wastewater reutilization in both water conservation and the addition of valuable nutrients and organic matter to farmland has only recently been thrust to the forefront. Although certain problems appear to exist in the accumulation of potentially toxic trace metals in crops grown on wastewater-amended fields, the overall beneficial effects are overwhelming.[16] The needs for irrigation water and inorganic fertilizers are strongly curtailed and plant yields increase significantly.

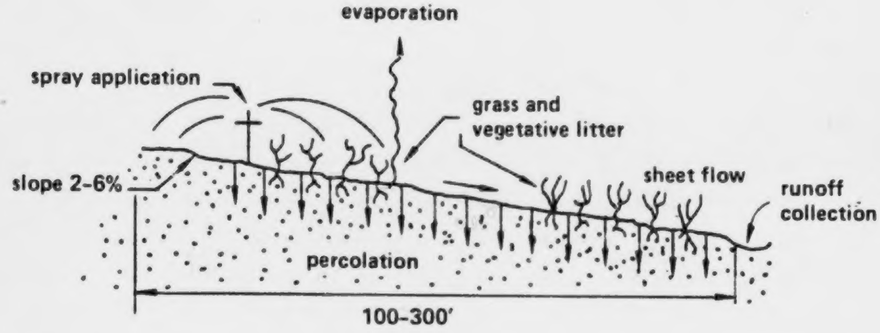
Despite the demonstrated usefulness of liquid wastewater, most municipalities still expend considerable time and energy in the drying of wastewater sludge. Municipal Chicago's West-Southwest Sewage Treatment Works, one of the largest treatment plants in the world, processes in excess of 635 dry metric tons of sludge per day, using at least 67,800 kilowatts of electricity per day in the sludge-drying process.[17] A plan now under consideration would eliminate the sludge-drying process, thereby saving millions of dollars in energy costs and millions of gallons of water every year.

Many field tests have been completed which support the efficiency of land application systems for recycling of wastewater. Several different techniques (spray irrigation, groundwater recharge by rapid infiltration, and overland flow; see fig. 4) have been applied with a large variety of waste materials (agricultural, municipal, and industrial). The U.S. Environmental Protection Agency (EPA) has published a design manual outlining factors to consider and design and evaluation procedures to facilitate wastewater usage.[18]

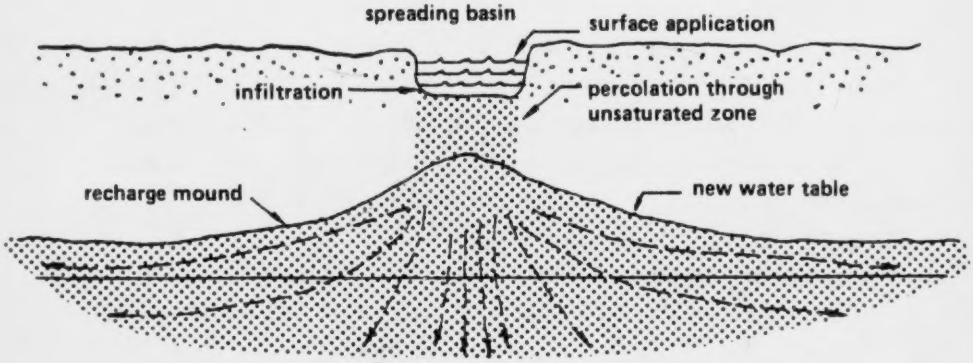
The city of Tallahassee, Florida, which began wastewater irrigation practices in the 1940s, was recently the site of an EPA study designed to document the effect of wastewater application on crop yields and soil characteristics.[19] Effluent from a secondary treatment plant was applied by spray irrigation to crops grown in fine, sandy soil. Summer crops included coastal bermuda grass, sorghum, millet, corn, and kenaf, while winter crops included rye and ryegrass. Summer irrigation rates were as high as 200 mm (8 inches) of water per week while up to 100 mm (4 inches) of water per week was applied to winter fields. In both summer and winter crops, yields increased with water application rate.



Spray irrigation



Overland flow



Rapid infiltration

Fig. 4. Examples of methods of land disposal of wastewater. (Adapted from S.C. Reed et al., *Waste Water Management by Disposal on the Land*. Special Report No. 171 [Hanover, N.H.: U.S.A. Cold Regions Research and Engineering Laboratory, 1972].)

The soil was very effective at removing fecal coliform bacteria from the effluent as well as phosphorus, while at high irrigation rates (more than 50 mm per week) some nitrogen percolated into the groundwater. Soil pH remained at around 6.5, in the optimum range for crop production.

In another study near Pauls Valley, Oklahoma, the overland flow method of wastewater application received extensive analysis.[20] Here, municipal wastewater equivalent to approximately one-third the average flow of domestic sewage from Pauls Valley, a community of about six thousand people, was applied to test sites exhibiting slopes of 2 and 3 percent. Each plot was seeded with a variety of grasses. Here again, bacterial numbers, biochemical oxygen demands, viral contaminants, and suspended solids were greatly reduced and infiltration of applied water was rapid.

The long-term effects of applications of domestic wastewater are documented in another EPA investigation.[21] On a test farm near Roswell, New Mexico, slow-rate irrigation of crops by wastewater has been in progress since 1944. Here, effluent flowing through a concrete-lined ditch was channeled to run down furrows in the fields. Analyses of water, soils, and plants at the Roswell site in 1977 indicated that the use of wastewater for irrigation resulted in several long-term benefits. No viruses or fecal coliform bacteria had penetrated the soils and reached underlying groundwater, nor were indicator viruses found either on the surfaces or inside leaf tissue or grain of corn grown on the effluent-irrigated land. Heavy metals such as zinc, copper, and chromium were not being assimilated at a greater rate in effluent-irrigated plants than in similar crops at nearby groundwater-irrigated sites. More toxic heavy metals such as cadmium, lead, and mercury were demonstrably absent from the irrigation effluent, the underlying groundwater, and the irrigated corn crop. Arsenic and selenium concentrations in effluent-treated soils have remained comparable to other soils in the area. In contrast, plant nutrients, nitrogen and phosphorus, have increased in the effluent-irrigated soil by about 50 percent, as contrasted with groundwater-irrigated soils. There was no indication of pesticide or herbicide contamination in effluent-irrigated soils.

This study suggested that the Roswell site could continue to be irrigated by effluent water for another hundred years without harmful effects. Not only did this process return scarce water back to soil and groundwater storage, but the city of Roswell realized an income of over

$11,000 in 1977 from the sale of effluent water to farmers, golf course operators, and other users.

How are wastewater reuse plans implemented in these days of high interest rates? What institutions are involved? In the fledgling Beaver Irrigation District near Lowell, Arkansas, a plan is currently being implemented that would access some of the 1 million gallons per day of backwash water produced in treatment plants in the Beaver Water District of northwest Arkansas.[22] A severe drought in 1980 was a financial blow to all northwest Arkansas farmers, with fruit farmers especially hard hit. Following the 1980 drought, public pressure fostered the formation of the irrigation district, which became a legal entity in May of 1981. Farmers in the area currently pay about $200 per acre-foot of irrigation water and, as one farmer said "the new system should cut that to less than $50. With production costs up 15 to 20 percent and berries up only around 5 percent, any savings we can manage is important" (Stubblefield 1982, p. 7).

Work is underway on putting together a contract with the Beaver Water District under which the irrigation district will pay the water district $100,000 for connection rights. In return, the irrigation district is to receive the wastewater free for twenty years. Eighteen area farmers with about 900 acres of crops are in the irrigation district and there will be enough water to irrigate over 1,000 acres.

Farmers must have storage capacity for half their allotment for the year, about 50 to 60 acre-feet, which would be stored in holding ponds. Construction of 4- and 12-inch plastic distribution lines, buried for protection, will probably start in the late summer of 1982. The costs for holding pond and pipeline construction will be subsidized by state and federal agencies; a $300,000 grant from the state office of the Soil Conservation Service and a $200,000 loan from the Farmers' Home Administration are already approved. An additional $300,000 in matching funds for holding pond construction with the Agricultural Stabilization and Conservation Service is pending.

Farmers see their work as more than just a way to fill a need on their own land. A local farmer who raises blueberries and strawberries in the district said, "This way we can use backwash water for a productive purpose that otherwise would cost additional funds to treat" (Stubblefield 1982, p. 7).

Clearly, the institutional support exists for a broad application of such plans across America. True, we need further research on the long-term effects of wastewater application on soil and climate types found in irrigation areas. But overwhelming evidence exists which says that wastewater reuse is an old idea whose rejuvenation time has come. One need only look at California, where a state report recorded that over 2 million acre-feet of wastewater are produced annually—a massive amount of water which could be used to stave off drought in the Central Valley, the coastal basin, and the San Joaquin basin.[23]

Current agricultural practices also cause other, more direct water resource problems which must be addressed. As noted earlier, agriculture has become the single biggest polluter of two-thirds of the U.S. river basins. Non–point source inputs of nutrients which fuel algal blooms and eroded soils degrade more freshwater supplies than industrial or residential inputs combined. Increasing quantities of toxic pesticides and herbicides now find their way into surface and groundwaters directly from agricultural sources. Unless agriculture-caused water pollution is sharply curtailed, clean water goals ordered by Congress simply cannot be met.

Clearly, these trends must be reduced. Wise land use practices must be returned to America's farmlands. Marginal land should not be used for grain production. Contour plowing must again become the norm. In 1977, Congress created a new Rural Clean Water Program, designed as an innovative effort to help farmers stop both farm-caused water pollution and soil erosion. These policies must become generally adopted. The farmer must realize that he cannot continue unwise practices "just one more year" in a vain effort to recoup past losses. To do so mortgages his future and that of all who depend on him for food and on water downstream from his farm for necessary consumption. Conservative farming techniques, like so many other water-conservative techniques we have already discussed, are cost-effective, both in the short and long runs.

Agriculturists must recognize the importance of buffer areas. Forested, natural growth areas must be retained or, if absent, developed to assist in control of erosion and effective recharge of groundwater aquifers. Intermittent windbreaks not only reduce wind-transported soil movement and losses, but also reduce soil evaporation and plant transpiration rates. Buffer vegetation areas between tilled land and surface waters slow runoff and allow greater time for percolation to groundwater, as well as reducing particulate and nutrient intrusion to surface streams, lakes, and reservoirs. Wetlands can serve as major groundwater recharge sites and should not be drained. The small amount of acreage held in these buffer zones will more than compensate for the short-lived economic gains obtained from total exploitation of every possible acre of land.

Those struggling with the alternatives to wise land use practices might ponder the words of Dr. Priscilla Grew, director of the Department of Conservation of California: "Where soil is lost, civilization also goes with it. Today soil is as essential for the production of food and fiber as it was during the Neolithic."[24] Truly, soil and water problems are interdependent; we cannot solve one without addressing the other. And solve them we must—our societal future depends on it.

Industrial Changes and Governmental Roles

Industrial consumption of water continues to rise every year in our demophorically expanding society. Much industrial water consumption involves one-time use and discarding of intake water for cooling or metal processing. Even in areas where water is relatively abundant, the industrial demand for water is increasing sharply. The Great Lakes Basin Commission estimates that as the human population of the region doubles between 1970 and 2020, the demand for Great Lakes water will increase tenfold, a perfect example of exploding demophoric growth in action.[25] These figures mean that approximately 100 billion gallons of water per day would be withdrawn from the lakes and returned in various stages of degradation. Today, up to 0.1 percent of the inshore waters of the Great Lakes are used every day for power plant cooling purposes. By the year 2000, that daily figure probably will exceed 1 percent in Lake Michigan and 3 percent in Lake Ontario.

The generation of electricity ranks second only to agriculture in withdrawals of water. In 1975, for example, steam electric generation cooling processes accounted for about 37 percent of all freshwater withdrawals in the United States.[26] However, *consumptive* use of water by these power plants amounts to only about 2 percent of the total U.S. consumption. Again, the major problem confronting designers and operators of steam electric generation plants is to increase the efficiency of cooling processes using water, so that less need be withdrawn from stressed freshwater supplies. Many power plants still utilize water withdrawn from surface or groundwater only once and then discharge it, simply because it remains inexpensive to do so. In situations where water is more limited, cooling ponds or cooling towers are often used. When cooling water is very scarce, dry cooling towers may also be used. In these systems, cooling water circulates in a closed system and heat is dissipated with little water loss, much like an automobile radiator. The point is that increased water efficiency in power plant cooling would go a long way toward forestalling water demand crises, particularly in urban areas poorly blessed with water reserves. The National Water Commission has estimated that general adoption of recirculating cooling systems would reduce this major freshwater demand to less than 2 percent of current levels and that higher water prices appear to be the most realistic incentive to foster such retrofitting.[27] The commission and other governmental agencies have recommended that government subsidies for water consumption, a common feature of this and other industries, must be curtailed, since they act as incentives for continued waste by making water artificially cheap. The commission has also emphasized that coastal states should make greater use of saline ocean water for cooling purposes, thus preserving fresh waters for other necessary uses. Florida, for example, has gone increasingly toward saline water cooling in power plants. Yet, many power plants in Florida and other coastal states continue to consume fresh waters for cooling, thus putting unnecessary demands on limited freshwater supplies.

Aside from electric generation, the Water Resources Commission in 1975 noted that manufacturing industries accounted for about 17 percent of the nation's freshwater withdrawal.[28] The commission also found that this water was recycled an average of 2.2 times before being returned to its source. Iron and steel, chemical, pulp and paper, petroleum refining, and food industries are all heavy users of water. The commission further projected that although total water use by manufacturing industries may increase fivefold by 2000, total freshwater and saline withdrawals could actually decrease by about 50 percent compared with 1975 levels if large-scale improvements were made in in-plant water recycling techniques. Clearly, without massive water recycling, manufacturing as a whole could face severe water limitation in the near future.

In addition, technological innovations which save water during the manufacturing process itself demonstrate that great improvements can still be made. For example, 1970 vintage pulp and paper mills employing available, newer technologies use about 62 percent as much water per ton of product as 1960 vintage plants. One avenue available to stimulate industrial water conservation is the strict enforcement of antipollution laws. If industry were forced by legal constraints to release smaller amounts of more highly purified water into the environment, every consideration would be made to limit the amount of water usage in the name of monetary savings. Here again is a perfect example of how stringent environmental regulations can actually benefit the long-term economic climate in the United States by limiting wasteful consumption of scarce resources.

Enlightened industrial concerns are already beginning to realize that it is in their own best interest to conserve water. Industrial cooperatives, consisting of a few plants to over thirty allied industrial concerns, are being set up all across America by private industry and are pooling resources to deal with problems of wastewater treatment and recycling and other water-related problems.[29] Do they work? Industrial managers say yes. Such cooperative schemes spread the costs of dealing with expensive problems to a number of different sources, saving everyone time and money. There are also state-level programs which assist industry with water-use credits, similar to energy credits, which pinpoint places a specific plant can save water. The Oklahoma Industrial Water Management program has estimated that in the past few years they have saved industrial clients some 36 million gallons of water. In a typical audit, water and energy cost savings pay back the price of an audit in less than a year.[30]

By necessity, governmental roles in industrial water conservation must be large. Presently, many industries are leaving the relatively water-rich areas of the Midwest and relocating in the water-poor southern and western regions. This trend is causing disproportionate demand for limited water in the South and West. As we have seen, this migration cannot long continue without fragile water reserves being decimated through competition among people, industry, and agriculture. The government's role in stemming this migratory flood could be considerable and is ultimately in the best interests of the country as a whole. Taxation laws on the local, state, and national level can be rewritten to encourage relocation of industries in areas supplied with adequate water. Taxation and depreciation allowances for new equipment should also reflect the real value of water as a limiting resource, just as we presently allow for energy-efficient retrofitting. Water-intensive practices and relocation of industry in water-poor regions may appear justifiable in the short term, but within several years, the real costs of water could make these factors economically prohibitive. The consumer, government, and industry must soon recognize the cost-benefits of sound water practices.

Fortunately, there is every indication that government and industry *are* recognizing the need for a new view of water conservation in the American economy. The Carter administration in 1978 proposed sweeping changes in governmental roles in the nation's water economy, stressing nonstructural, conservationist methods as the cornerstone of sound water policy.[31] Economic chaos in the intervening years threaten to undermine such work, as a stressed economy seeks to rewrite environmental legislation denounced as fiscally irresponsible. If anything has been stressed in this book so far, it is that *there is no inherent conflict between sound economics and sound resource utilization.* As a nation, we must resist the temptation to relax the vigilant control and supervision of those who would despoil *common* resources for personal gain, for, inevitably, we as consumers eventually pick up the tab. That tab will be many times greater than the cost of effective resource utilization at all stages of use.

But government and industry do not simply have a responsibility to reduce water usage. One of the most pressing acute and chronic water problems we face is the question of toxic waste disposal. We have already discussed the potentially catastrophic effects of toxic waste dumps on both surface and groundwaters, and the degradative effects of airborne contaminants. As we discover more and more of these dump sites and learn more about atmospheric contamination problems like acid rain in the years to come, the scope of the problem will become truly immense.

Only recently have industries responsible for introduction of wastes into the environment been held responsible for their actions. Inevitably, though, the cleanup efforts which have been proposed have been financed directly or indirectly from taxation of individual citizens (a good example is the proposed Three Mile Island cleanup plan currently being formulated). The safe disposal of toxic chemicals and industrial pollutants must become a top priority of industry. Water resources and the atmosphere itself must be recognized as common property and treated as such. One adage from the early environmental movement still holds true—nothing ever "goes away." Toxic waste disposal should become a recognized part of doing business, and, by definition, these costs must be borne by the consumers of products. From an energetic/economic standpoint, cleanup of wastes before they become dispersed in the aquatic, terrestrial, or atmospheric environment is always infinitely cheaper and easier than after-the-fact efforts. We must pay sooner or later. If later, the costs in both economic and human terms are staggering and intolerable.

Another concern must be addressed by industrial consumers of water. Presently, particularly in regions poor in surface waters, groundwater is pumped from deep aquifers, used for industrial purposes, and then released into surface systems. We have seen that groundwater recharge rates are much slower than those of surface systems. To prevent rapid depletion of precious groundwater aquifers, water taken from subsurface aquifers must, after cleanup, be returned to these sources. Furthermore, whether surface or subsurface water is used in industrial processing, the liquid water volume returned to the environment must meet or exceed that volume initially removed from the source. Losses of liquid water through evaporation and runoff can be immense and result in large net losses of water from areas which can ill afford deficits.

Water-conservative practices in industry, as those already discussed in the residential and agricultural fields, are economically beneficial now. They will become even more cost-effective in the future. Clearly, there is no conflict here between what is "good for industry" and what is good for the United States as a whole.

General Water Supply/Resupply Changes

We cannot long take more water from existing supplies than that which comes in through natural recharge processes. As we have seen, there is little we can do about increasing precipitation, a driving force of the hydrological cycle. There is much, however, that we can do to improve the effectiveness of precipitation in recharging surface and groundwater supplies. We can reduce demand for water through conservation, but that may not be enough, particularly if climatic change reduces the potential recharge rate of the nation's water supplies.

One way to increase recharge rates is to increase the amount of time water is in contact with the continental land mass before it flows out to sea. River channelization, which increases the water flow-through rate of river systems, is an unwise practice and should be curtailed sharply. It is argued that channelization reduces the threat of flooding in low-lying areas, but the evidence for this viewpoint is controversial. A critical eye should be directed toward any proposed channelization project. These projects are inconsistent with maximizing water recharge rates.

Many land use practices which decrease recharge rates must be reevaluated and changed. Our national goal should, whenever possible, be to preserve important water retention sites. We are beginning to realize the real economic value of heretofore "useless" wetlands and other natural buffer areas. Clear-cut deforestation, spreading patches of concrete which increase quantities and rates of urban runoff, and the drainage of wetlands are incongruous with the important goal of maximizing our precious water supplies. They simply do not make economic sense any longer, even in the short run.

In every part of the country, water resource problems now and in the future will have their own unique character. In each of these regions, specific benefits and debits should be weighed so that a reasonable, comprehensive regional water policy may be adopted. We have seen that the geopolitical influence of a large urban area far exceeds its geographical boundaries. Such regional water planning makes sense in the ebb and flow of water in the hydrosphere. Whatever policy a particular region adopts, it must maximize water strengths while minimizing demands on weak links in the system. For example, areas which depend almost exclusively on groundwater, particularly those in coastal regions, must rely increasingly on more rapidly replaced surface waters.

Concluding Remarks

How will we as a people respond to chronic water limiting conditions? If we refuse to recognize the problem we are destined to repeat the mistakes of past societies. No one can predict the uncertainties of the future. Anyone who examines the current and projected situation cannot fail, however, to be impressed with the magnitude and importance of water problems in any formula for an increasingly prosperous United States society. No one can fail to ponder the implications for the world situation if the United States can no longer meet its obligations as a net food exporter and world leader. Yet, in hard economic times, like those extant in the early 1980s, we are tempted to reduce spending and commitments of talent to solving problems which, on the face of it, seem not to be economically important. We have stressed over and over the real economic value of usable water to the American society. The mood of government, industry, and the American people is uncertain. The temptation is to return to "business as usual," and abandon progress made on understanding the basic and applied aspects of water research. The temptation is great to relax, rather than strengthen, policies which recognize the common property concept of water resources.

We are faced with a great challenge, one which will dwarf the energy crisis by comparison. For while we can substitute other forms of energy for oil or gas, we cannot substitute techological alternatives for water. Water crises, unlike other crises, develop slowly. Because they are slow to evolve, man classically addresses only their acute and visible manifestations. To prosper in the next century, we must turn away from this notion. We must, in short, become the first advanced techological society in the history of man to directly address his own techological limitations—and the first to progress beyond societal adolescence in a resource-limited biosphere.

NOTES

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2. *Final Report on Phase I of Water Policy Implementation*, Report Submitted to the President by the Secretary of the Interior, June 6, 1980, pp. iii–iv.

3. W. Viessman, Jr. and C. DeMoncada, *State and National Water Use Trends to the Year 2000*, a report prepared by the Congressional Research Service for the U.S. Senate, Serial No. 96–12, (Washington, D.C.: U.S. Government Printing Office, 1980), pp. 257–59. These figures represent a national average; estimates vary from about 118 gallons per capita to the more often quoted 250 gallons per day *consumed* by a family of four.

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Lakes Program, all of which suggest that shoreline modification is an important part of lake restoration.

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11. Report by Jack Stone to Conference on Horizons in Water Research, Water Research Institute, Oklahoma State University, Stillwater. Oklahoma, April, 1982.

12. Interagency Task Force, *Irrigation Water Use and Management*, pp. 1–10, 13.

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31. Final Report on Phase I of Water Policy Implementation, Appendix A.

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WHAT IS THE MOST EFFECTIVE WATER POLICY FOR THE UNITED STATES?

An Annotated Bibliography on the 1985-1986 National High School Debate Topic

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INTRODUCTION

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WHAT IS THE MOST EFFECTIVE WATER POLICY FOR THE UNITED STATES?

I. GENERAL

America's water: current trends and emerging issues. Washington, D.C., Conservation Foundation, 1984. 114 p. (An Issue report)

"The material in this book appeared in slightly different form in the Conservation Foundation, State of the environment, an assessment at mid-decade (1984)."

Ashworth, William. Nor any drop to drink. New York, Summit Books, 1982. 272 p.

Presents an overview of water supply and water quality concerns in the U.S. Topics addressed include the hydrologic cycle; water demand in cities and on farms; groundwater depletion; water supply problems resulting from sewage, acid rain, nuclear power, and salinity; water planning. Includes a bibliography of about nine pages.

Chan, Arthur H. The structure of Federal water resources policy making. American journal of economics and sociology, v. 40, Apr. 1981: 115-127.

Author posits that "rigorous enforcement of the National Environmental Policy Act and Council on Environmental Quality Interim Guidelines, revision of cost-sharing formulae and financing and reimbursement policies, improved flexibility of agency leadership, recruitment of new talents and ideas to agency ranks, and adjustment of agency orientation are needed for comprehensive planning to achieve social goals."

Chase, Edith B., John E. Moore, and David A. Rickert. Water Resources Division in the 1980's: a summary of activities and programs of the U.S. Geological Survey's Water Resources Division. Reston, Va., U.S. Dept. of the Interior, Geological Survey [for sale by the Supt. of Docs., G.P.O.] 1983. 78 p.

Describes the mission, organization, source of funds and major programs of the agency holding principal responsibility within the Federal Government for providing hydrologic information and appraising the Nation's water resources.

Council for Agricultural Science and Technology. Water use in agriculture: now and for the future. Ames, Iowa, 1982. 28 p. (Council for Agricultural Science and Technology. Report no. 95)

Presents an overview of the physical, institutional, economic, and sociological aspects of water use in agriculture, as well as a brief review of some of the current controversial issues.

Council on Environmental Quality (U.S.) The Nation's waters. In its Environmental quality 1983: 14th annual report. Washington, 1983. p. 70-120.

Presents an overview of the condition of the Nation's waters and highlights trends in the context of the dynamic and ecological processes that govern quality and quantity of water. Discusses freshwater (surface and groundwater) as well as estuarine and marine waters, with special focus on the quality of estuarine and marine waters. Includes a 160-item bibliography on water quality.

Davis, Joseph A. Water projects await funding as debate over cost sharing stalls action on Capitol Hill. Congressional quarterly weekly report, v. 41, July 1983~~: 1551-1558.~~

The discussion of the politics of water projects includes a case study of the Garrison Diversion in North Dakota.

Degenhardt, Christopher, and Stephen Smith. Water management for urban landscapes. Urban land, v. 42, July 1983: 10-14.

Discusses the implications of the rising cost of good water.

Efficient investments in water resources: issues and options. Washington, U.S. Congressional Budget Office, 1983. 59 p.

"This study analyzes three options that are under Congressional or Administrative consideration. Each recognizes the changing nature of water development responsibilities and aims to combine cost-sharing reform with financing mechanisms and changes in decision making processes that, taken together, would promote a more efficient water resources investment program."

Estimated use of water in the United States in 1980. Reston, Va., U.S. Dept. of the Interior, Geological Survey [for sale by the Supt. of Docs., G.P.O.] 1983. 56 p. (Geological survey circular; 1001)

Presents data on water use for household supply, rural areas, irrigation, industry, thermoelectric power, and hydroelectric power.

Ferguson, Bruce K. Whither water? The fragile future of the world's most important resource. Futurist, v. 17, Apr. 1983: 29-36.

"Wells are drying up and river flows are declining, yet we continue to waste water and hasten its flow to the sea. If there is to be enough water in the future to meet the growing demand, we must find ways to reuse and recapture the finite amounts flowing through the water cycle."

Francko, David A., and Robert G. Wetzel. To quench our thirst: the present and future status of freshwater resources of the United States. Ann Arbor, University of Michigan Press, 1983. 148 p.

Discusses the two broad classes of water problems: (1) problems in water supply and demand, and (2) problems in degradation of water supplies and of the terrestrial environment necessary for effective water supply recharge. Stresses the real economic value of water and asserts that "corrective measures to reduce inefficient consumption, use and degradation of existing water supplies can be accomplished with existing technology without losses of real economic productivity."

Frederick, Kenneth D. Current water issues. Journal of soil and water conservation, v. 39, Mar.-Apr. 1984: 86-91.

Discusses water quality, demand, and law. Makes a case for water markets for irrigation and also suggests that for water quality and streamflow issues, "correcting for market failures may be a better policy approach than completely abandoning the market system."

Getches, David H. Water law in a nutshell. St. Paul, Minn., West Pub. Co., 1984. 439 p. (Nutshell series)

Contents.--Overview and introduction to water law.--Riparian rights. Prior appropriation.--Hybrid systems and other variations.--Groundwater.--Diffused surface waters.--Federal and Indian reserved rights.--Federal power over water development.--Interstate allocation.--Water service and supply organizations.

Defines and summarizes major concepts in water law.

Hales, William W. Use and reuse of water. Chemtech, v. 12, Sept. 1982: 532-537.

"To use water is not necessarily to consume it. Technologists' aim is to reduce the amount of water industry uses and discards."

Hamilton, Robert A. What will we do when the well runs dry? Harvard business review, v. 62, Nov.-Dec. 1984: 28-30, 32, 36, 38, 40.

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Johnson, Steven L., and David E. Winslow. The national water supply: its impact on availability and cost of water. Industrial development, v. 152, May-June 1983: 26-31.

"Most assessments of the national water supply have been either too gloomy or too rosy. Actual per capita water use is 10 times what was once supposed, but the real shortage is one of water developments and water works, not water."

Maranto, Gina. The creeping poison underground. Discover, v. 6, Feb. 1985: 74-78.

Describes the nationwide problem of groundwater pollution, which "almost all environment scientists" agree is the "main environmental challenge of the coming decade." Discusses clean-up techniques, which are very costly, and legal prospects for groundwater protection.

Measuring water quality: an inventory by the States. EPA journal, v. 10, Jan.-Feb. 1984: 12-15.

Summarizes the findings of the latest EPA National Water Quality Inventory.

Metzger, Philip C. Nationally significant studies of water policy: a review of major water policy studies and assessment of present issues. Washington, Conservation Foundation, 1983. 53 p.

Critiques over two dozen studies. "The studies were reviewed chronologically, the studies' findings, assumptions, and recommendations were divided among sixteen issue classifications, and a subjective assessment was made of the 'trends of analysis' on and of the ultimate effectiveness and relevance of each study. Finally, cross-cutting themes, which seem best to describe the present needs for water policy analysis and political attention, were sifted from the issue review." Suggests areas for further policy research.

Morandi, Larry B., and Greg H. Lazarus. Water resources management: issues and policy options. Denver, National Conference of State Legislatures, 1982. 63 p.

This report summarizes a longer report of the same name. It emphasizes the policy considerations of surface water supply and groundwater overdraft.

Mosher, Lawrence. Localities begin to challenge Government's water policy 'vacuum'. National journal, v. 16, Jan. 28, 1984: 164-168.

"Problems associated with water supply and water quality are becoming evident in all parts of the country. In Washington, however, water policy remains fragmented." Article highlights an October 1983 report on water by the Labor Management Group, the activities of the newly formed congressional National Water Alliance, and current legislative initiatives.

National water summary, 1983: hydrologic events and issues. Reston, Va., U.S. Dept. of the Interior, Geological Survey. Washington [For sale by the Supt. of Docs., G.P.O.] 1984. 243 p. (U.S. Geological Survey water-supply paper; 2250)

Contents.--Man and the hydrologic cycle.--Selected hydrologic events for January 1982 through August 1983.--Hydrologic perpectives on water issues.--State water issues.

Discusses issues of water quality, water availability, hydrologic hazards and land use, and water institutions and management. Presents data and summaries of water issues for each state.

Opie, John. Scarcity amidst plenty: the problem of water. In 1983 yearbook of science and the future. Chicago, Encyclopedia Brittanica, Inc., 1982. p. 196-209.

"The U.S. is not running out of water but it will become dramatically more expensive. . . . Providing adequate amounts of fresh water in the future poses a major challenge."

Pimentel, David, and others. Water resources in food and energy production. BioScience, v. 32, Dec. 1982: 861-867.

"Conflicts for water between US agriculture and energy sectors are projected to increase. Currently agriculture consumes 83% of the water withdrawn, and an increase of 17% is projected by the year 2000. At the same time, a major synfuel program from coal and oil shale could increase water consumption for energy production 4-to 30-fold over present levels. A significant portion of this growth in water demand will occur in the western states where most irrigated agriculture and one-half of US coal reserves are located. Environmental restrictions and the necessity to maintain aquatic ecosystems are additional constraints."

Pye, Veronica I., and Ruth Patrick. Ground water contamination in the United States. Science, v. 221, Aug. 19, 1983: 713-718.

"Ground water contamination is of increasing concern in the United States because about 50 percent of our drinking water comes from well water. The causes of contamination stem from both point sources and non-point sources. . . . Deleterious effects on human health have resulted from pathogenic organisms in ground water and from its toxic chemical composition. It is difficult to estimate the extent of contamination on a national basis as the frequency of instances of contamination is very variable. Remedial actions to clean up aquifers are difficult, expensive, and sometimes not feasible. Many of the laws and regulations that control ground water contamination are designed with other main objectives."

Rogers, Peter. The future of water. Atlantic monthly, v. 252, July 1983: 80-88, 90-92.
"The threats to the resource are real, but not insurmountable."

Sander, William. Federal water resources policy and decision-making: their formulation is essentially a political process conditioned by government structure and needs. American journal of economics and sociology, v. 42, Jan. 1983: 1-12.
"The effects that politics, government structure, and economic standards have upon federal water resources planning are examined. Water resources policy decisions are treated as a product of political demands which, in turn, are examined as a product of the direct or indirect stakes, or perception thereof, in a policy. Government structure also affects decisions, since it affects political access and, subsequently, power as well as the administrative capacity of government."

Schooler, Dean, and Helen Ingram. Water resource development. Policy studies review, v. 1, Nov. 1981: 243-254.
The authors describe the "roles and influence of the states and the federal government through three distinct periods of federl-state water policy" from Federal domination in the 1950s to emerging State domination today.

Sheaffer, John Richard, and Leonard A. Stevens. Future water: an exciting solution to America's most serious resource crisis. New York, W. Morrow, 1983. 269 p.
Argues that "the national water crisis is not a shortage of water, but the mismanagement of ample supplies that we already have," and illustrates how traditional disposal-by-dilution treatment methods have failed. Advocates "circular" water treatment systems and argues that the profit motive, not new legislation, can solve water problems.

Sheets, Kenneth R. War over water: crisis of the '80s. U.S. news & world report, v. 95, Oct. 31, 1983: 57-60, 62.
"The U.S. water supply is unevenly distributed, most of it concentrated in the eastern half of the country and in the Pacific Northwest. Even there, reserves are being stretched thin as more rivers, lakes and aquifers become polluted and undrinkable."

State of the environment: an assessment at mid-decade. Washington, Conservation Foundation, 1984. 586 p.
See especially pages 105-132, which discuss water quality; pages 134-144, which discuss water use, and pages 365-417, which focus on water resource issues of conflicting values, interstate and intrastate conflicts, and financial responsibility.

Stokes, Bruce. Water shortages: the next "energy crisis". Futurist, v. 17, Apr. 1983: 37-41, 45-47.
"By the year 2000, population growth alone will at least double the demand for water in half the countries of the world."

Tofani, B. Joseph. For our water: a program, not projects. Water spectrum, v. 13, fall 1981: 17-23.
Asserts that water resources projects have been implemented piecemeal. Urges the development of a water program for each of our major river basins.

Trelease, Frank J. Uneasy federalism--State water laws and national water uses. Washington law review, v. 55, Nov. 1980: 751-775.
Article examines the uneasy coexistence of State and Federal water laws.

U.S. Congress. House. Committee on Government Operations. Environment, Energy, and Natural Resources Subcommittee. Review of ground water protection strategy recently proposed by the Environmental Protection Agency. Hearings, 98th Congress, 2nd session. Apr. 11 and 12, 1984. Washington, G.P.O., 1984. 611 p.

U.S. Congress. House. Committee on Science and Technology. Subcommittee on Natural Resources, Agriculture Research and Environment. Agriculture and water use: present and future issues. Hearing, 98th Congress, 1st session. Oct. 25, 1983. Washington, G.P.O., 1984. 92 p.
"No. 65"

U.S. General Accounting Office. Water conservation: an update of Federal activity; study by the staff. Washington, G.A.O., 1983. 28 p.
"GAO/RCED-83-113, Apr. 22, 1983"
"This study discusses the Federal Government's efforts to encourage water conservation and the philosophy underlying them."

----- Water issues facing the Nation: an overview; study. Washington, 1982. 30 p.
"GAO/CED-82-83, May 6, 1982".
This study identifies issues and problems relating to water resources; it also "focuses GAO's audit efforts of the Federal Government's direct and indirect involvement with water-related matters."

U.S. National Water Commission. Water policies for the future; final report to the President and to the Congress. Washington [For sale by the Supt. of Docs., G.P.O.] 1973. 579 p.
Partial contents.--Water and the economy.--Water pollution control.--Improving water-related programs.--Improving organizational arrangements.--Federal-State jurisdiction in the law of waters.--Indian water rights.--Financing water programs.
Despite its age, this volume still outlines the current water policy agenda.

The United States Government Manual 1984/85. Prepared by U.S. Office of the Federal Register. Washington, G.P.O., 1984. 913 p.
Use the subject/agency index to locate information about Federal agencies with responsibilities for water resources.

Water: resource at the brink. American forests, v. 90, Aug. 1984: 17-28, 30-33, 37-33, 49-51, 62-63.
Contents: Groundwater, buried treasure by Frank Forrester; and: The hydrologic cycle; Uses, abuses and attitudes; The balance sheet; What about tomorrow?; all by Barbara Tufty.

Water: we can't live without it. National wildlife, v. 22, Feb.-Mar. 1984: 7-21.
Contents.--The magnificent liquid of life, by F. Powledge.--Making do with less, by G. Alexander.--Is it safe to drink?, by J. Carey.--Nurseries of life, by M. Levinson.

Water in America 1983: a report by the Office of Water Policy, Department of the Interior, to accompany the U.S. Geological Survey's National Water Summary 1983. Washington [For sale by the Supt. of Docs., G.P.O.] 1983. 18 p.
"Provides a special look at six of the most urgent water issues facing us today," focusing on river management, interstate water conflicts, water project development, Indian water claims, acid rain, and salinity. Discusses Federal and State responses to these issues, which highlight changing Federal/State roles.

Water wars. USA today, Jan. 30, 1984: 10A.
Includes the newspaper's editorial opinion that "a national water policy is needed to sort out conflicts over water among states and competing interests, an opposing view from Wisconsin, other views from California, Montana, and Texas, and voices from across the USA."

Waters and water rights; a treatise on the law of waters and allied problems: Eastern, Western, Federal. Edited by Robert Emmet Clark. Indianapolis, A. Smith Co., 1967-76. 7 v.
Presents a comprehensive look at water law.

II. RESOLVED: THAT THE FEDERAL GOVERNMENT SHOULD IMPLEMENT A NATIONAL SYSTEM OF PRIORITIES TO CONTROL THE ALLOCATION OF ALL WATER IN THE UNITED STATES.

Anderson, Terry L. Water crisis: ending the policy drought. Washington, Cato Institute, 1983. 121 p.
"Develops the logical arguments for a private market in water rights and describes the advantages of such a market." Advocates the return to "the original concept of the appropriation doctrine which permitted transfers of water from one area, one use, and one owner to another, relatively freely and without many governmental restrictions. . . . [D]escribes in some detail how this might work and anticipates some of the objections that will be raised."

Banks, William C. Conservation, federalism, and the courts: limiting the judicial role. Syracuse law review, v. 34, summer 1983: 685-742.
Article examines "diverse interests in conservation as an important current example of how federalism's structural implications--the allocation of decision-making authority between Nation and states--have been misapplied to make inconsistent and bad constitutional law and confused social policy." Discusses FERC v. Mississippi and Sporhase v. Nebraska as examples of misapplied federalism principles. Author suggests "limiting the judicial role on both sides of the commerce clause inquiry."

Bates, Karl Leif. Water diversion from the Great Lakes. Illinois issues, v. 10, Dec. 1984: 17-20.
"Among Illinois' chief resources is water. As an asset in economic development, abundant fresh water is key to this state and the region. This article explores a greater dimension of this resource--diversion of water from the Great Lakes--possibly beyond the states and Canadian provinces in the basin."

Bittinger, Morton W., and Elizabeth B. Green. You never miss the water till .... : the Ogallala story. Fort Collins, Colo., Resource Consultants; Littleton, Colo., Water Resources Publications, 1980. 116 p.

Presents a nontechnical description and analysis of water problems in the High Plains (western Nebraska, and Kansas, eastern Colorado and New Mexico, the "panhandle" sections of Texas and Oklahoma, and parts of South Dakota and Wyoming. This region depends on groundwater forming the Ogallala aquifer, a source which is rapidly being depleted.

Clyde, Edward W. Allocation of water for resource development. Natural resources lawyer, v. 14, no. 3, 1982: 519-540.

Article discusses the problem of obtaining sufficient water rights for major energy projects in the West. Explores the possibility of using irrigation water rights to obtain the necessary water.

Coats, Robert. The Colorado River: river of controversy. Environment, v. 26, Mar. 1984: 7-13, 36-40.

Reports on the 1983 "Colorado River Working Symposium: Management Options for the Future," where seven major issues emerged. Emphasis was on avoiding lawsuits as a way of resolving Colorado River conflicts.

Competition for Southwestern water is changing water law and management strategies. Santa Fe, N.M., Western Network, 1984. 6 p. (Decision no. 4)

Summarizes three water disputes: the efforts of El Paso to use groundwater from New Mexico; the conflict between Los Angeles and residents of the Owens Valley over groundwater pumping; and the conflict of the Ak-Chin Indian Community with the City of Yuma over water rights.

Conference proceedings: the Pick Sloan Missouri Basin Plan. Omaha, Neb. Missouri Basin States Association, 1983. 89 p.

Proceedings of a conference held August 10-11, 1983 in Des Moines, Iowa to review the aspirations of 40 years ago and note problems that still remain to be solved. Recent lawsuits regarding transfer of water out of the Missouri River basin also provided impetus for review of this important basin development plan.

Corker, Charles E. Sporhase v. Nebraska ex rel. Douglas: does the dormant commerce clause really limit the power of a State to forbid the export of water and the creation of a water right for use in another State? University of Colorado law review, v. 54, spring 1983: 393-445.

"In Part I this article concludes that the Court failed to understand the basic necessities, rooted in laws of the physical universe, which demand active local government management of water resources. Part II focuses on the Court's failure to articulate dormant commerce clause doctrine which can accommodate the diverse and local necessities of a federal union of continental size. . . . Part III considers possible federal and state legislation."

Cox, William E. Establishment and maintenance of water rights in the Eastern United States. Agricultural law journal, v. 4, spring 1982: 53-76.

Discusses differences in water law in the Western and Eastern U.S. and the differences among the Eastern States.

Davis, Tony. Trouble in a thirsty city. Technology review, v. 87, Aug.-Sept. 1984: 66-71.

Reports how Tucson, which has no supply of surface water, relies on groundwater "mining" now, and will rely on water from the Central Arizona Project in the next decade. Discusses possible water shortages for agriculture and costs of water.

DeLambert, Deborah A. District management for California's groundwater. Ecology law quarterly, v. 11, no. 3, 1984: 373-400.

"This Comment recommends the creation of a statewide program of local groundwater management authorities to regulate California groundwater. Such a solution was urged by the 1978 Report of the Governor's Commission to Review Water Rights Law, but has not been enacted by the Legislature." Reviews the issues and options, and argues for adoption of the Commission's proposals.

DuMars, Charles, and Helen Ingram. Congressional quantification of Indian reserved water rights: a definitive solution or a mirage? Natural resources journal, v. 20, Jan. 1980: 17-43.

Article recounts the history of the Navajo Indian Irrigation Project and the current controversy surrounding the project. Describes technical, administrative and legal issues involving the project, and analyzes the way in which water conservation attempts by the Navajo have worked against their own interests.

Emerging issues in water management and policy. Edited by Sandra S. Batie and J. Paxton Marshall. Mississippi State, Miss., Farm Foundation; Southern Rural Development Center, 1983. 83 p. (SRDC series no. 58)

Southern Natural Resource Economics Committee. SNREC publication no. 17.Southern Extension

Southern Extension Public Affairs Committee. SEPAC publication no. 4.

Presents papers from a June 1982 workshop held in Blacksburg, Va. Topics addressed are: water rights, water law, water use and availability in the South; governments' roles and responsibilities in water management; alternative water management strategies; and the university's role in water research and education.

Federal-State rights and relations. In Waters and water rights; a treatise on the law of waters and allied problems: Eastern, Western, Federal. Volume two, and supplement to volume two. Edited by Robert Emmet Clark. Indianapolis, A. Smith, 1967, 1978. p. 1-109; p. 1-63.

"Examines the constitutional bases of federal activity and the extent to which they derogate state control and result in the taking, with or without compensation, of state-created private water rights."

Fisher, Todd A. The Winters of our discontent: Federal reserved water rights in the Western States. Cornell law review, v. 69, June 1984: 1077-1093.

Comment deals with Federal reserved water rights vs. rights established by prior appropriation. "By strictly defining federal reserved rights to make them mesh as smoothly as possible with the water law systems of the various states, the Court's well-directed efforts to harmonize the two doctrines can ease the tension between the Winters doctrine and the prior appropriation doctrine."

Gernerd, Kurt A. Protecting instream flows. Water spectrum, v. 14, spring 1982: 35-45.

Water resource development has often reduced the quantity and quality of the natural flows of streams. Provides background on this problem and lists legislation and executive orders providing directly or indirectly for the protection and maintenance of instream flows. Lists 26 strategies for reserving instream flows for fish and wildlife.

Greider, Thomas. Instream flows, the State and voluntary action. Cato journal, v. 3, winter 1983-1984: 811-830.

Advocates private ownership of instream flows.

Grier, Peter, Brad Knickerbocker, and Julia Malone. Pork barrel politics today. Christian Science monitor, May 3, 1983: 1, 5; May 4: 6; May 15: 13; May 6: 4.

Contents.--As Senate begins debate on the budget, critics look at proposals and find projects ripe for trimming, by P. Grier.--Garrison diversion: needed, or a clear case of 'pork'? by P. Grier.--Trying to find the pork in the Pentagon's barrel, by B. Knickerbocker.--Deficit-wary Congress cuts back on pork barrel projects, by J. Malone.

Hansen, Kevin. South Florida's water dilemma: a trickle of hope for the Everglades. Environment, v. 26, June 1984: 14-20, 40-42.

Reports how peninsular Florida, the wetlands that comprise Everglades National Park, is threatened by poor water resources management that have disrupted the annual cycles of flooding and drying.

Holden, Constance. Day of reckoning for the Garrison project. Science, v. 225, Aug. 31, 1984: 904-906.

"The Interior Department, at the behest of Congress, has appointed a 12-member commission headed by former Louisiana governor David C. Treen to decide the fate of the project, including a possible alternative plan, by 31 December. . . . But unless two-thirds of the commission agree to halt or modify the project, it will proceed as planned."

Hope, Barney, and Michael Sheehan. The political economy of centralized water supply in California. Social science journal, v. 20, Apr. 1983: 29-39.

"California over the course of the last century has had more than its share of conflict over water policy, first over the question of which private interests would control the state's water resources and later over how and in whose interests water would be supplied publicly. This paper presents an analysis of how water policy in California has dealt with the problems of private water monopolies, economies of scale and the incentive to centralize the water supply function. The economic superiority of public over private provision of water is demonstrated, and the role and effect of large-scale special interests in the formulation of public policy are described."

Kiker, Clyde F. Water allocation in the East. Federal Reserve Bank of Georgia economic review, June 1981: 27-31.

"After reviewing the evolution of water doctrine in the East, Dr. Kiker proposes an alternative plan which would maintain a water authority's power to manage the overall supply but would also make possible private transactions among water users."

Kovalic, Joan M. Funding to meet America's water needs. Professional engineer, v. 52, winter 1982: 28-35.

"We must presume that there will be steadily declining federal subsidies for water-related public works facilities. The federal spigot is literally being turned off. It is time to reassess priorities, to rebuild the self-sufficiency of local and state revenue systems, and to reestablish a critical working partnership of state and local government and the business and professional communities."

Kneese, Allan V. High Plains, low water. Resources, no. 78, fall 1984: 7-9.

Describes the Six-State High Plains-Ogallala Aquifer Regional Resources Study of 1982, which examined strategies for addressing the problem of depleting groundwater supplies in the High Plains region. Concludes that although the Ogallala aquifer is depleting, there is no water crisis there, and that "water importation is a thoroughly bad idea."

Lukas, Teresa N. When the well runs dry: a proposal for change in the common law of ground water rights in Massachusetts. Boston College environmental affairs law review, v. 10, Sept. 1982: 445-502.

The present system of ground water rights has been characterized as the "rule of the biggest pump." This article describes the hydrology of ground water and proposes a rule to replace the present inadequate doctrine.

McNulty, Michael F., and Gary C. Woodard. Arizona water issues: contrasting economic and legal perspectives. Arizona review, v. 32, fall 1984: 1-13.

Discusses water allocation and water pricing issues in Arizona, particularly ownership of recharged groundwater, problems new water users will have in acquiring Central Arizona Project water, and Indian water rights.

Martin, James, and Thomas Jensen. Indian reserved water rights: a primer for resource managers. Western wildlands, v. 9, winter 1984: 2-5.

Matthews, Olen Paul. Water resources, geography and law. Washington, Association of American Geographers, 1984. 82 p. (Resource publications in geography)

Contents.--The nature of water and its use.--Law and resource use.--Public use of rivers and lakes.--The allocation of water rights.--Boundary changes.--Policy issues and future research.

Peck, John C. Legal aspects of water storage in Federal reservoirs in Kansas. Kansas law review, v. 32, summer 1984: 785-836.

This article addresses the general nature of storage rights and water reservation rights (reservoir storage) in particular under Kansas law. Discusses sale of stored water under water reservation rights. "Interspersed throughout the Article and concluding it are suggestions about possible federal rights to water flowing in and out of these reservoirs and to the impounded water itself."

Pfaff, Timothy. California's peripheral canal. Environment, v. 24, Apr. 1982: 25-35.

Discusses "a 43-mile-long ditch that would link the state's northern rivers to water delivery systems supplying Southern California. The contoversy stirred by the canal is based not only on its potential environmental impacts but also on the issues of land development; who will pay for the canal, its pumping facilities, and the water it delivers versus who will receive its benefits; whether the water is actually needed; and whether the canal is the best solution of California's water allocation problems."

Powledge, Fred. Water: the nature, uses, and future of our most precious and abused resource. New York, Farrar Straus Giroux, 1982. 423 p.

This book addresses both water supply and water quality issues. See especially section two, "The Exploiters," for material on competing water demands, and section three, "Water and Pork," for material on water projects.

Radin, Charles A. On the coast. Boston globe, July 1, 1984: 1, 18; July 2: 1, 18; July 3: 1, 4; July 4: 1, 16; July 5: 6-7; July 6: 1, 6.

Contents.--Pressures, uses ever-changing on N.E. coastline.--Falmouth lab takes valuable chemical from crabs.--Coastal towns fear impact of condos.-Fishermen vent ire on condominium plan.--What changing views on erosion have done.--State's salt marshes are victims of flaws in wetland enforcement.-Duck stamps aid marshes.--Mass. water cleanup bid only in infancy.--Preservation, privacy achieved by limiting access.

Riley, John. The water wars. National law journal, v. 7, Feb. 18, 1985: 1, 45-51.

Describes legal water issues in Western States: prior appropriation doctrine, Indian water rights, and out-of-state water export.

Rubin, Kenneth. Current cost-sharing and financing policies for Federal and State water resources development: special study. Washington, Congressional Budget Office, 1983. 84 p.

Contents.--Introduction and overview.--Nominal and effective cost-sharing policies for Federal and State water resources development.--Financing State water resources development.--Constraints on State and local financing.

Russell, Bob. Federal reserved water rights: the need for negotiation. Western wildlands, v. 9, winter 1984: 6-9.

Concludes that "there can be no remaining doubt that the federal government has reserved rights for nonconsumptive, in-stream water uses where such uses further the purposes of the individual reservations" and "conversely, it is pointless for the federal government to assert pie-in-the-sky claims for reserved water that already belongs to someone else under state law."

Schwartz, Edward B. Water as an article of commerce: State embargoes spring a leak under Sporhase v. Nebraska. Environmental affairs law review, v. 12, no. 1, 1985: 103-169.

"The Sporhase decision is important because it makes possible a significant shift in authority over water rights and distribution away from the states to the federal government." This article concludes that "although the Supreme Court was correct in finding that there are no available arguments which would entirely exempt water embargo statutes from commerce clause treatment, the commerce clause is a clumsy tool with which to balance the complex, competing federal and state interests in this area. The more appropriate decision might have been to defer to the Congress to resolve this dispute."

Stokes, Bruce. Bread and water: irrigation policies and politics. Sierra, v. 68, Mar.-Apr. 1983: 39-42, 44, 46.

Discusses the need for improved management of irrigation: "To be successful in the long run, the technical, managerial and, ultimately, the political processes of irrigation development require a new water ethic to help balance the complex interests involved in developing water resources for agriculture."

Tarlock, A. Dan. So its not "ours"--why can't we still keep it? A first look at *Sporhase v. Nebraska*. Land and water law review, v. 18, no. 1, 1983: 137-174.

"In this article the author examines the United States Supreme Court's recent decision in *Sporhase v. Nebraska*. He discusses the implications the decision has for Western States' attempts to control their water resources and suggests a revision in the Court's approach to such questions."

U.S. Congress. House. Committee on Agriculture. Subcommittee on Conservation, Credit, and Rural Development. Effects of interbasin water transfers on agriculture. Hearing, 98th Congress, 1st session, on H.R. 1749. June 15, 1983. Washington, G.P.O., 1983. 211 p.

"Serial no. 98-16"

U.S. Congress. Senate. Committee on Banking, Housing and Urban Affairs. Subcommittee on International Finance and Monetary Policy. Prohibition of the exportation of fresh water. Hearing, 98th Congress, 2nd session, on S. 2239. June 7, 1984. Washington, G.P.O., 1984. 86 p. (Hearing, 98th Congress, 2nd session, S. Hrg. 98-887)

"To amend the Export Administration Act of 1979 to prohibit the exportation of fresh water in bulk by tanker."

U.S. Congress. Senate. Committee on Energy and Natural Resources. Subcommittee on Water and Power. Ground water recharge in the High Plains States; and delivery of water to the North Platte Irrigation Project. Hearing, 98th Congress, 1st and 2nd sessions, on S. 1811, H.R. 71, and S. 1590. Parts 1 and 2. Washington, G.P.O., 1984. 2 v. (135, 91 p.) (Hearings, Senate, 98th Congress, 1st and 2nd sessions, S. Hrg. 98-469)

Hearings held in Washington, Sept. 29, 1983; in Woodward, Okla., Feb. 17, 1984.

U.S. Congress. Senate. Committee on Environment and Public Works. Subcommittee on Water Resources. The impact of the Supreme Court decision in *Sporhase versus Nebraska*. Hearing, 97th Congress, 2d session, Sept. 15, 1982. Washington, G.P.O., 1982. 154 p.

"Serial no. 97-H63"

----- Water resources policy issues. Hearings, 97th Congress, 1st session, Parts 1 and 2. Washington, G.P.O., 1981. 2 v. (1010, 580 p.)

"Serial no. 97-H14"

Hearings held Apr. 21-June 12, 1981, and June 16-July 24, 1981.

U.S. General Accounting Office. Federal-interstate compact commissions: useful mechanics for planning and mapping and managing river basin operations; report to the Congress by the Comptroller General of the United States. Washington, 1981. 41 p.

"CED-81-34, Feb. 20, 1981"
"This report describes the major interstate water problems existing within the Delaware and Susquehanna River Basins and discusses how the two existing Federal-interstate compact commissions work to solve these problems."

Viessman, Warren, Jr., and Claire Welty. Water management: technology and institutions. New York, Harper & Row, 1985. 618 p.
See especially Chapter 3, "Water Policy and Insitutions," which covers policy formation processes, government roles, State and Federal law, regulations, traditions and customs, organizations, and politics, and Chapter 5, "Economics and Financing," which applies economic theory to the planning, design, and management of water resource systems.

Water in the West: the well runs dry. Economist, v. 287, May 14, 1983: 41-42, 45-46, 49-50.
"Anybody who has seen a few cowboy movies knows that in the American west people used to be shot because of water. It is still something to be fought over. Indeed, no public issue is more important to westerners than water. Its scarcity constrains their economic development. It sets the tone of their relations with the federal government and is behind many of their most bitter quarrels with one another."

Water rights: scarce resource allocation, bureaucracy, and the environment. Edited by Terry L. Anderson. San Francisco, Calif., Pacific Institute for Public Policy Research; Cambridge, Mass., Ballinger Pub. Co., 1983. 348 p. (Pacific studies in public policy)
"The story of the allocation of agricultural and urban water supplies in the United States, reprinted and analyzed in this book, is full of extremely useful lessons: about what the market can and cannot do, and about how and why state intervention, capable in principle of making things better, is likely to make things much worse." Topics addressed in this collection of essays include water pricing, groundwater privatization, instream use, pollution rights, institutional governance of water rights, and other water allocation issues.

Wengert, Norman, and Emery N. Castle. Land, people and policy. Journal of soil and water conservation, v. 37, Jan.-Feb. 1982: 14-20.
A two part article gives the "western view" of emerging independence described by Wengert and a "national view" in which Castle offers solutions to the possibly growing regional conflict.

Whittlesey, Norman K. Irrigation development in the Pacific Northwest: a mixed blessing. Environmental law, v. 10, winter 1980: 315-329.
This article estimates total energy costs of irrigation development, including water lost to hydroelectric generating power, which should be considered when water allocations "increase benefits of one sector of society at the expense of another."

Wilder, Julia R. The Great Lakes as a water resource: questions of ownership and control. Indiana law review, v. 59, 1984: 463-501.

"As the Great Lakes become legally recognized as a national water resource, a specialized forum will be needed to allocate water and to mediate disputes arising from interstate sales of usufructuary rights and the resulting transcontinental diversions of Great Lakes water. The author advocates the establishment of a regional requisitionary forum, containing those basic features outlined in this Note."

Wright, William C., Ronna Cohen, and Jeffrey H. Heath. Decentralizing water resource planning and management. Journal of the American Water Works Association, v. 74, July 1982: 334-345.

"The historic tug of war between federal, state, and local agencies for water resource control has contributed greatly to problems facing the water industry. States are in the best position to coordinate varied interests and to refocus emphasis on local input. Integrating water management techniques with ongoing state water planning offers public assurance of continuing reliable and cost-effective water service."

III. RESOLVED: THAT THE FEDERAL GOVERNMENT SHOULD ESTABLISH A COMPREHENSIVE NATIONAL POLICY TO PROTECT THE QUALITY OF WATER IN THE UNITED STATES.

Acid rain. American Water Works Association journal, v. 76, Mar. 1984: whole issue.

Contents.--Effects of acid rain on water supplies in the Northeast, by F. Taylor and G. Symons.--The dilemma of an acidic sky, by T. Jenkins. --The 7 effects of acid precipitation runoff on source water quality, by R. Liebfried, W. Sharpe, and D. DeWalle.--Current research on the effects of acid deposition, by J. Perry.--Acid precipitation and drinking water supplies, by J. Reed and J. Henningson.

Bastian, Robert K., and Jay Benforado. Waste treatment: doing what comes naturally. Technology review, v. 86, Feb.-Mar. 1983: 59-66, 69.

"By taking advantage of nature's recycling systems, cities can reduce the steadily increasing cost of treating sewage while putting this 'resource' to productive use."

Changing the Clean Water Act: reflections on the long-term. Journal of the Water Pollution Control Federation, v. 55, Feb. 1983: 123-129.

The author concedes the need to fine-tune the Clean Water Act and offers some long-term proposals in order "to reflect the political and economic realities and the technical knowledge that have been gained since the original act was passed in 1972."

Chemical rivers: cleaner today--but clean enough? Chemical week, v. 131, Sept. 29, 1982: 60-64.

Outlines the present state of pollution of several U.S. rivers. Chemical contamination is much improved since 1972. Warns that the continuing lack of agreement between EPA and the chemical industry on what constitutes "best available technology" threatens the eventual quality of the Nation's rivers.

Chemical water: winners and losers in the coming crisis. Chemical week, v. 134, Feb. 22, 1984: 34-39.

"Perhaps the most compelling reason for more concern about water availability by the chemical industry is the sheer size of its requirements." Warns the industry that planning for the year 2000 starts now.

The Clean Water Act with amendments. Washington, Water Pollution Control Federation, 1982. 132 p.

Presents a synopsis of the Federal Water Pollution Control Act and discusses how it came to be, tracing Federal water pollution legislation from 1948-1972 and explaining subsequent amendments. Reprints the text of the Act, as amended.

Christensen, Lee A., and Patricia E. Norris. Soil conservation and water quality improvement: what farmers think. Journal of soil and water conservation, v. 38, Jan.-Feb. 1983: 15-20.

Reviews research on farmers' attitudes about the control of nonpoint water pollution through soil conservation and other practices. The attitudes are diverse and often conflicting. Includes references.

Cleary, Edward J. Frustrated aspirations for watershed quality management. Journal of the Water Pollution Control Federation, v. 53, Mar. 1981: 291-298.

Advocates having the various river basin commissions implement water pollution control on the basis of water quality standards rather than requiring them to enforce uniform, technology-based effluent standards.

Dames and Moore. Trends in U.S. groundwater law, and administration, prepared for the Groundwater Task Force of the Edison Electric Institute. Washington, The Institute, 1984. 1 v. (various pagings)

Tracks Federal, State, and local trends in groundwater management, with particular attention to strategies in certain "bellweather" jurisdictions. Among report's conclusions is that the trend of addressing groundwater management issues at State and local levels will continue.

Feliciano, Donald V., and John E. Blodgett. Protecting groundwater: a new environmental frontier? Congressional Research Service review, v. 5, Feb. 1984: 14-16.

Discusses the evidence on groundwater contamination and reviews existing Federal legislation which addresses the problem. Presents three options for protecting this resource.

Gaba, Jeffrey M. Federal supervision of State water quality standards under the Clean Water Act. Vanderbilt law review, v. 36, Oct. 1983: 1167-1219.

"This Article argues, based on the provisions and history of the Clean Water Act and the problems of federal implementation of minimum requirements, that states essentially should have a free hand in the designation of uses and that the federal role in water quality standards should be limited to enforcing a stringent antidegradation requirement and supervising the states' scientific judgments in establishing pollutant levels."

Garrett, Theodore L. EPA, Congress reviewing pretreatment program. Analysis and perspective, v. 4, Apr. 5, 1982: 17, 19, 25.

Article discusses the future of the Federal industrial pretreatment program, and suggests that "consideration should be given to the development of a new approach that allows pretreatment requirements to be established locally rather than by EPA."

Groundwater protection strategy. Washington, U.S. Environmental Protection Agency, 1984. 55 p.
Finds that groundwater management is primarily a State responsibility which Federal authorities support. The EPA strategy states that "EPA will provide support to States for program development and institution building; will address contamination from underground storage tanks; will study the need for further regulation of land disposal facilities, including surface impoundments and landfills; will adopt guidelines for consistency in its ground-water protection programs; will improve its own institutional capability to protect ground water."

Guida, Joseph F. Dramatic growth in citizen suits under the Federal Clean Water Act. National law journal, v. 7, Dec. 3, 1984: 24, 26.
Discusses legal and policy questions raised by the rise of citizen suits against industrial waste-water dischargers. Both individual and environmental organizations have been using this strategy for enforcement of the Clean Water Act.

Has the time come to rescue Chesapeake Bay? Conservation Foundation letter, Mar.-Apr. 1984: 1-6.
"Concern about the harmful effects on the estuary's vegetation, fish, wildlife, and recreational values has triggered a surge of political action. This has included passage of new legislation in Maryland to deal with various sources of pollution, particularly runoff from the land. The most dramatic new law establishes a system for controlling development along the shoreline to minimize impacts on bay water quality."

Hughes, Marcia M. Federal laws, State water regulation, and section 404. State government, v. 55, fall 1982: 127-132.
"Section 404 provides that the Secretary of the Army, acting through the Chief of the Army Corps of Engineers, may issue permits after notice and opportunity for public hearing for the discharge of dredged or fill material into navigable waters at specific disposal sites." Discusses the implications of this and the prohibition against Federal interference with State allocation systems.

Jolly, Carol A. State and Federal roles in national water cleanup. State government, v. 55, fall 1982: 115-118.
Concludes "in the states' view, actual implementation of the Clean Water Act's expressed policy of state primacy is the best means of promoting future accomplishments. . . . States must have the flexibility to administer their programs in the most streamlined, cost-effective manner possible and the authority to become the principal managers with full responsibility for delegated programs. In turn, the states will accept accountability, both to EPA and to their citizens."

Marshall, Brian R., and James C. Lamb, III. Evolving water quality regulations. State government, v. 55, fall 1982: 122-126.

The authors discuss the Clean Water Act and conclude that "making the necessary changes in laws and regulations could provide more efficient water quality protection than building unnecessary additions to treatment plants, or by wasting funds and energy necessary to operate plants at levels unjustified by water quality requirements of receiving streams."

Miller, George. Crisis at Kesterson: wastewater and wildlife in California's Central Valley. Sierra, v. 69, Mar.-Apr. 1984: 30-31, 76-77.

To remedy the wastewater problem in California's irrigated Central Valley, the San Luis Drain was designed to carry polluted water to the Sacramento/San Joaquin Delta. However, the Drain currently dumps wastewater in Kesterson reservoir, causing toxic affects at the Kesterson National Wildlife Refuge. Article describes the situation at Kesterson and urges that it not be repeated elsewhere.

Milliman, Jerome W. Can water pollution policy be efficient? Cato journal, v. 2, spring 1982: 165-196.

Contends that the present water pollution policy of direct regulation of discharges is expensive, wasteful, and ineffective. Enumerates the advantages effluent charges and tradable permits have over direct regulation.

National water quality inventory: 1982 report to Congress. Washington, U.S. Environmental Protection Agency, 1984. 63 p.
"EPA 440/2-84-006"

Based on reports submitted by the states in 1982, this document summarizes progress to date and finds that "the Clean Water Act is working." Identifies toxic substances pollution, groundwater contamination, and groundwater depletion as issues of national concern.

Needs survey report to Congress: assessment of needs of publicly owned wastewater treatment facilities in the United States, 1984. Prepared by U.S. Environmental Protection Agency, Office of Municipal Pollution and Control, and Roy F. Weston, Inc. Washington, 1985. ca. 125 p. in various pagings.

Summarizes the EPA's 1984 assessment of needed publicly owned wastewater treatment facilities, presenting data on the capital investment required in meeting the needs of 1984 population as well as the additional amount needed for population growth through the year 2000. Examines the potential, aggregate impacts of needed municipal facilities on future water quality.

Nonpoint water pollution: a special issue. Journal of soil and water conservation, v. 40, Jan.-Feb. 1985: whole issue (p. 8-114)

Partial contents.--Policies for nonpoint-source water pollution control, by W. Harrington, A. Krupnick, and H. Peskin.--Paying the nonpoint pollution control bill, by L. Libby.--State initiatives in nonpoint source pollution control, by R. Savage.

Point . . . and counterpoint: groundwater contamination. Environmental forum, v. 2, Jan. 1984: 26-32.

Presents the views and policy recommendations of the chairman of the Interstate Conference on Water Problems Ground Water Task Force (Mr. Williamson), and General Counsel of the Environmental Defense Fund (Mr. Tripp), Senior Consultant on CH2M's water quality study for a California water district (Mr. Gaston), and chairman of the Chemical Manufacturers Association Ground Water Management Task Force (Mr. Werner).

Prothro, Martha, Theodore L. Garrett, and Alan S. Miller. Point . . . and counterpoint: pretreatment toxics variances. Environmental forum, v. 2, Apr. 1984: 28-32.

The Third Circuit Court of Appeals has invalidated EPA's "fundamentally different factors" variance regulations for dischargers of toxic pollutants subject to pretreatment standards under the Clean Water Act. The Reagan Administration has asked Congress to override the decision, and the Chemical Manufacturers Association has asked for Supreme Court review. Article presents three points of view.

Pye, Veronica I., Ruth Patrick, and John Quarles. Groundwater contamination in the United States. Philadelphia, University of Pennsylvania Press, 1983. 315 p.

This study shows that groundwater contamination has occurred in most parts of the country and will probably continue to occur. Both scientific and legal aspects of the problem are explored. One conclusion is that "the prevention of the contamination of useful, potable aquifers is far superior to subsequent curative efforts. This can, in part, be achieved by regional planning and the enforcement of federal and state regulations designed to protect groundwater."

Report to Congress: nonpoint source pollution in the U.S. Washington, U.S. Environmental Protection Agency, 1984. 1 v. (various pagings)

Contents.--Nature and extent of the nonpoint source problem.--Identification of high-payoff problem areas and expected results.--Current programs directed at controlling nonpoint source pollution.--Looking ahead: managing nonpoint sources.

Results of the nationwide urban runoff program. Washington, U.S. Environmental Protection Agency, 1983. 24 p.

Summarizes the results of a study of the effects of urban stormwater runoff on water quality.

Schoenbaum, Thomas J. Environmental policy law: cases, readings, and text. Mineola, N.Y., Foundation Press, 1985. 1011 p. (University casebook series)

See Chapter 5, "Water Pollution," for excerpts of judicial decisions dealing with effluent standards, thermal and toxic pollutant effluent standards, receiving water considerations, oil spills, and other water quality issues.

Schneider, Keith. Pollution alley: Louisiana's petrochemical legacy. Amicus journal, v. 6, fall 1984: 26-35.

"Three decades of oil and gas drilling, refining, and chemical manufacturing have left a legacy of contamination unparalleled in the Deep South and rivaled, perhaps, only by New Jersey." Presents an environmental history of Louisiana, which has unusually high cancer rates. Calls New Orleans' municipal water supply one of the country's most dangerous; EPA studies have identified sixty-six potential carcinogenic chemicals and hundreds of other toxic compounds in the city's drinking water.

Siegel, Lenny. High-tech pollution. Sierra, v. 69, Nov.-Dec. 1984: 58-64.

Describes water pollution from leaking underground storage tanks in Silicon Valley. Trichloroethane and trichloroethylene are among the groundwater contaminants.

Study of the future Federal role in municipal wastewater treatment. Prepared by the U.S. Environmental Protection Agency. Washington, 1984. ca. 135 p. in various pagings.

Recommends a gradual transition from Federal responsibility to State and local financial self-sufficiency for wastewater treatment as required by the Clean Water Act. Presents background information on current financing mechanisms and an analysis of Federal funding options.

Thomas, Frank M., Jr. Public water systems and Superfund: recovering losses caused by contamination. American Water Works Association journal, v. 75, Aug. 1983: 385-389.

The Comprehensive Environmental Response, Compensation, and Liability Act "was enacted as a means of protecting surface waters and groundwaters from contamination caused by releases from inactive waste disposal sites and by spills. The statute encourages public water systems to take the initiative in protecting their own sources of supply by allowing them to recover their costs, either from responsible parties or from the Hazardous Substance Response Trust Fund."

U.S. Congress. House. Committee on Government Operations. Groundwater protection: the quest for a national policy; fifty-fifth report. Washington, G.P.O., 1984. 132 p. (Report, House, 98th Congress, 2nd session, no. 98-1136)

U.S. Congress. House. Committee on Merchant Marine and Fisheries. Subcommittee on Fisheries and Wildlife Conservation and the Environment. Fish cancer epidemics oversight. Hearing, 98th Congress, 1st session. Sept. 21, 1983. Washington, G.P.O., 1984. 115 p.

"Serial no. 98-40"

"Hearing on the causes of reported epidemics of cancer in fish and the relationship between these occurrences and environmental quality and human health."

U.S. Congress. House. Committee on Public Works and Transportation. Water Quality Renewal Act of 1984; report together with additional and supplemental views to accompany H.R. 3282 including cost estimate of the Congressional Budget Office. Washington, G.P.O., 1984. 91 p. (Report, House, 98th Congress, 2nd session, no. 98-827)

U.S. Congress. Office of Technology Assessment. Protecting the Nation's groundwater from contamination. Washington, O.T.A. [for sale by the Supt. of Docs., G.P.O.] 1984. 2 v. (244, 503 p.)

"OTA-O-233, OTA-O-276"

Volume I assesses the current status of U.S. knowledge and experience in dealing with groundwater contamination. The analysis indicates that despite growing efforts, Federal and State programs are narrow in focus and limited in their ability to protect against contamination. Volume II consists of appendixes and presents in detail the information and data on which the analyses and conclusions of Volume I are based.

U.S. Congress. Senate. Committee on Environment and Public Works. Subcommittee on Environmental Pollution. American attitudes toward clean water. Hearing, 97th Congress, 2nd session. Dec. 15, 1982. Washington, G.P.O., 1983. 20 p.

"Serial no. 97-H68"

Testimony of Louis Harris about his poll on "American Attitudes Toward Clean Water" commissioned by the National Resources Council of America, the Fishing Tackle Manufacturers Association and the Rockefeller Brothers Fund.

U.S. General Accounting Office. Federal and State efforts to protect ground water; report to the Chairman, Subcommittee on Commerce, Transportation and Tourism, Committee on Energy and Commerce, House of Representatives. Washington, G.A.O., 1984. 80 p.

"GAO/RCED-84-80, Feb. 21, 1984"

Presents information on the nature and scope of groundwater contamination and on Federal and State roles in its control. "The 15 states GAO contacted favored a federal role, primarily in the areas of funding and research and development, but generally opposed strong federal regulatory controls."

----- Wastewater dischargers are not complying with EPA pollution control permits; report to the Administrator, Environmental Protection Agency. Washington, G.A.O., 1983. 61 p.

"GAO/RCED-84-53, Dec. 2, 1983"

"The Clean Water Act's National Pollutant Discharge Elimination System limits the type and amount of pollution a municipal or industrial facility may legally discharge into the nation's waterways." GAO estimated the degree to which these permit limits were exceeded. The EPA relies on self-monitoring by dischargers and thus is not aware of all noncompliance which may continue for a long time. "GAO makes several recommendations to the Administrator, EPA, for improving the permit program."

U.S. Library of Congress. Congressional Research Service. Federal-State relations in transition: implications for environmental policy; a report prepared by the Congressional Research Service of the Library of Congress for the Committee on Environment and Public Works, U.S. Senate. Washington, G.P.O., 1982. 99 p.

"Serial no. 97-7"

At head of title: 97th Congress, 2nd session. Committee print.

Want, William L. Federal wetlands law: the cases and the problems. Harvard environmental law review, v. 8, no. 1, 1984: 1-54.

Surveys "the essential procedural and substantative aspects of wetlands law. The first part examines the scope of the Corps of Engineers' jurisdiction under the two principal federal statutes that protect wetlands: the Rivers and Harbors Act and the Clean Water Act. Part II considers several aspects of judicial review of Corps Wetlands permit decisions. The last two Parts survey defense and relief available in wetlands cases."

Ward, Bud. Amending the Clean Water Act - framing the issues for debate. Environmental forum, v. 3, Feb. 1985: 18-21.

The Clean Water Act is up for reauthorization in 1985. This article outlines the issues that may be addressed and the political forces surrounding possible legislation.

Washburn, Jack, and others. Industrial pretreatment needs to be overhauled at the national level. Journal of the Water Pollution Control Federation, v. 53, Oct. 1981: 1452-1456.

Reviews the current state of national pretreatment policy and recommends improvements: especially encouragement by the Federal Government of strong State and local programs to ensure the pretreatment of industrial wastewater before discharge into municipal systems.
v. 53, Oct. 1981: 1452-1456.

Water Quality Committee. [Annual report] Natural resources lawyer, v. 16, no. 2, 1983: 359-405.
"The 1982 Annual Report of the Water Quality Committee is divided into three parts. Part I covers legislative, judicial and administrative developments under the Clean Water Act (CWA). Part II covers judicial and administrative developments under the Safe Drinking Water Act. Part III discusses developments respecting private rights of action and the federal common law of nuisance."

Wyche, Bradford W. The regulation of toxic pollutants under the Clean Water Act: EPA's ten year rulemaking nears completion. Natural resources lawyer, v. 15, no. 3, 1983: 511-536.
Article focuses on EPA's ten-year struggle to establish regulatory controls on toxic pollutants under the Clean Water Act. It reviews the history of the litigation, analyzes the Federal district court's three substantive opinions issued during 1982, and considers the possibility of legislative intervention.

Yates, Edward E. Federal water pollution laws: a critical lack of enforcement by the Environmental Protection Agency. San Diego law review, v. 20, July 1983: 945-962.
This Comment reviews the statutory history of the Federal Water Pollution Control Act Amendments of 1972. "Congress should enact now what was suggested over a decade ago: a mandatory enforcement provision backed by a citizen-suit provision to force water pollution control officials to carry out their duties."

IV. RESOLVED: THAT THE FEDERAL GOVERNMENT SHOULD ESTABLISH A NATIONAL POLICY TO INSURE EACH UNITED STATES RESIDENT AN ADEQUATE SUPPLY OF POTABLE WATER FOR PERSONAL USE.

Asinof, Richard. The good, the bad and the ugly: the search for safe drinking water in America. Environmental action, v. 14, May 1983: 22-25.
Suggests that water quality is more a political than scientific matter and that it is also strongly influenced by how much people are willing to pay to protect public drinking water supplies.

Baumann, Duane D., and Danial Dworkin. Water resources for our cities. Washington, Association of American Geographers, 1978. 35 p. (Resource papers for college geography; no. 78-2)
Examines the interrelated problems of municipal water supply and waste treatment. "Once we recognize the linkage between water supply and waste treatment, opportunities arise for reusing treated wastewater to supply the city when alternative sources are not readily available. These opportunities are not simple. We must answer questions of public health, acceptability, and economics before cities can reuse substantial portions of their wastewater.

Cobb, Edwin L., and Mary E. Morgan. Drinking water supplies in rural America. Washington, National Demonstration Water Project, 1978. 164 p.

Contents.--The need for rural water facilities.--Current efforts to provide adequate rural water service.--Problems in rural water development. --Future options for dealing with rural water problems.

Drinking water supplies, protection through watershed management, by Raymond J. Burby, and others. Ann Arbor, Mich., Ann Arbor Science, 1983. 273 p.

Besides discussing technical aspects of watershed management, presents an overview of why watershed management is important and how it is currently practiced throughout the United States. "Urbanization of water supply watersheds is creating an increasing serious hazard to public health. . . . Water supply systems and local governments must devise watershed management strategies that incorporate a variety of measures and institutional arrange- to protect raw water supplies from contamination."

Dzurik, Andrews A. Water use and public policy in Florida. Journal of water resources planning and management, v. 110, Apr. 1984: 167-179.

"The interrelations of water use, population growth, and urbanization in the state of Florida are examined. Although the greatest freshwater use is for irrigation, the paper focuses on municipal use because of its projected increase and because it suffers the greatest problems in times of water shortage." Also reviews the "legal and administrative structure, and some of the policy considerations for water use decisions in Florida. From this information, it is apparent that the state and the water management districts must continue to pursue an integrated frame work for municipal water supply planning and decision making. Especially important is the need to prepare water shortage plans for periods of excess demand or drought."

How to make sure there's enough good water. U.S. news and world report, v. 98, Mar. 18, 1985: 65-68.

Presents the views of eight congressmen who have formed the National Water Alliance. They assert that the U.S. is confronting a water crisis and that the Nation needs a comprehensive water policy.

Keough, Carol. Water fit to drink: a guide to the hidden hazards of drinking water and what you can do to ensure a safe, good-tasting supply for the home. With special contributions and technical assistance from Patricia M. Nesbitt. Emmaus, Pa., Rodale Press, 1980. 265 p.

Discusses Federal inaction on drinking water pollution control, describes contamination and its causes, and presents ways for individuals to supply their own pure water.

Markwood, Ira M. Possible carcinogens in water - how serious the problem? Water engineering and management, May 1983: 14,68.

Argues that "[we] must be cautious in our approach to control possible carcinogens, but we must, by all means, not lose our objectivity and demand overstrict regulatory limits. This approach would drain an appreciable amount of money from other much more valuable areas into expensive water treatment costs which would have little or no beneficial effect on public health."

Middleton, Paulette, and Steven L. Rhodes. Acid rain and drinking water degradation. Environmental monitoring and assessment, v. 4, Mar. 1984: 99-103.

"Acid depostion-induced drinking water degradation is discussed with respect to the geographical extent of and the potential for dealing with possibly adverse human health impacts. Qualitative evidence from the northeastern United States and Sweden strongly suggests the existence of a linkage between these two environmental concerns. It is argued that water treatment and reduction of acid rain as solutions to the problem of water toxicity need closer evaluation. More research into the causal link is warranted since the addition of human health impacts to acid rain's environmental insults could have a significant bearing on discussions relating to acid controls."

National Research Council (U.S.) Safe Drinking Water Committee. Drinking water and health. Washington, National Academy Press, 1977-1983. 5 v.

Summarizes research on toxicity levels of chemicals in drinking water. Surveys the literature for information on potential risks to humans posed by chronic exposure to these chemicals in water supplies.

National statistical assessment of rural water conditions: summary. Sponsored by the U.S. Environmental Protection Agency, Office of Drinking Water. Springfield, Va., National Technical Information Service, 1984. ca. 135 pages in various pagings.

Presents the first systematic national assessment of the quantity, availability, cost and affordability of rural domestic water. Examines the rural drinking water situation and finds that most rural households have a water supply which is acceptable by most quality indicators; is in sufficient quantity to meet consumption demands; is readily available on a continuous basis; has a reasonable cost; and is affordable.

National Water Conservation Conference on Publicly Supplied Potable Water (1981 : Denver, Colo.) Proceedings of the National Water Conservation Conference on Publicly Supplied Potable Water: April 14-15, 1981, Denver, Colo., edited by Dynamac Corporation; sponsored by U.S. Environmental Protection Agency (EPA) . . . et al . . Washington, U.S. Dept. of Commerce, National Bureau of Standards; Springfield, Va, National Technical Information Service, distributor, 1982. 492 p. (NBS special publication; 624)

"Techniques for, and analysis of, potable water conservation and wastewater flow reduction were presented. The topics addressed included: water-saving technology: plumbing fixtures, testing and performance of low-flow devices, leak detection and repair, potential problems in wastewater flow reduction, and landscaping with native vegetation; public education and motivation; economics: water pricing systems, analysis of cost/benefits, and development and management of data; planning: State and local urban planning efforts for conservation, and Federal programs and incentives; case studies: from California, Washington, Utah, Arizona, North Carolina, Maryland, New Jersey, and Massachusetts."

Point . . . and counterpoint: Safe Drinking Water Act amendments. Environmental forum, v. 3, May 1984: 26-31.

Presents views of Congressmen Dennis Eckhart and Ed Madigan; Donald Boyd, of the Association of Metropolitan Water Agencies; and John Capriccioso of the Halogenated Solvent Industry Alliance.

Safe drinking water: the impact of chemicals on a limited resourse. Edited by Rip G. Rice. Alexandria, Va., Drinking Water Research Foundation; Chelsea, Mich., Lewis Publishers, 1985. 275 p.

Based on a symposium sponsored by the Drinking Water Research Foundation and the American Chemical Society, this volume presents two essays on national and international perspectives on drinking water; three on sources and distribution; six on chemicals in drinking water; two on monitoring and analysis; and six on regulatory aspects.

Singer, Grace L. Nor any drop to drink!: public policies toward chemical contamination of drinking water. Princeton, N.J., Center for Energy and Environmental Studies, Princeton University, 1982. 1 v. (various pagings) (PU/CEES report no. 140)

Report provides an overview of various public policy issues relating to chemical contamination of drinking water, focusing on national and State perspectives.

U.S. Congress. House. Committee on Energy and Commerce. Subcommittee on Health and the Environment. Safe Drinking Water Act Amendments of 1983. Hearings, 98th Congress, 1st session on H.R. 3200. Washington, G.P.O., 1983. 911 p.

"A bill to amend the Safe Drinking Water Act (title XIV of the Public Health Service Act) to authorize appropriations for the fiscal years 1984 through 1987, to insure the prompt promulgation of drinking water regulations, to improve enforcement procedures, and to provide greater protection for underground sources of drinking water."

U.S. Congress. House. Committee on Government Operations. Environment, Energy, and Natural Resources Subcommittee. Ground water contamination. Hearings, 98th Congress, 1st session. Washington, G.P.O., 1984. 630 p.

Hearings held June 22, 23, and 29, 1983.

U.S. Congress. Senate. Committee on Environment and Public Works. Subcommittee on Toxic Substances and Environmental Oversight. Safe Drinking Water Act Amendments of 1984. Hearings, 98th Congress, 2nd session, on S. 2649. Washington, G.P.O., 1984. 359 p. (Hearings, Senate, 98th Congress, 2nd session, S. Hrg. 98-951)

Hearings held May 14; June 11 and 26, 1984.

U.S. General Accounting Office. States' compliance lacking in meeting safe drinking water regulations; report to the Administrator, Environmental Protection Agency. Washington, 1982. 22 p.

"CED-82-43, Mar. 3, 1982"

U.S. Library of Congress. Environment and Natural Resources Policy Division. A legislative history of the Safe Drinking Water Act; together with a section-by-section index. Washington, G.P.O., 1982. 1103 p.

"Serial no. 97-9"

"Printed for the use of the Senate Committee on Environment and Public Works."

At head of title: 97th Congress, 2nd session. Committee print.

Warren, Jacqueline M. Water, water everywhere. Amicus journal, v. 3, summer 1981: 15-21.

Finds "drastic inadequacy in the response of U.S. water supply officials to widespread chemical water pollution resulting from the mushrooming chemical and petrochemical industry of the past three decades."

Zeldin, Marvin. Our drinking water: a threatened resource. 1st ed. New York, Public Affairs Committee, 1983. 24 p. (Public affairs pamphlet; no. 613)

WHAT IS THE MOST EFFECTIVE WATER POLICY FOR THE UNITED STATES?

A Guide to Information Sources on the 1985-1986 National High School Debate Topic

by
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April 1, 1985

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A GUIDE TO INFORMATION SOURCES
on the 1985-1986
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INTRODUCTION

This research guide identifies sources of information on water policy and related topics that will be discussed by high school debaters. The guide describes indexes and other research tools, and provides appropriate search terms that might be used when consulting these tools.

The guide is divided into two parts. The first part describes basic research sources and lists the search terms which can be used when examining these tools. The second part describes specialized water policy reference sources.

Search terms, which may be used separately or in combination, are provided for each resolution of the debate topic.

I. RESOLVED: That the Federal Government should implement a national system of priorities to control the allocation of all water in the United States.
(ALLOCATION OF WATER)

II. RESOLVED: That the Federal Government should establish a comprehensive national policy to protect the quality of water in the United States.
(WATER QUALITY)

III. RESOLVED: That the Federal Government should establish a national policy to insure each United States resident an adequate supply of potable water for personal use.
(POTABLE WATER)

Throughout the guide, the resolutions are referred to in the abbreviated form listed in parentheses above.

The search terms listed for each of the topics are not exhaustive. The primary terms are included to help the high school debater begin his search for materials on these topics.

RESEARCH SOURCES

This is a listing of research tools described in this guide, listing pages where each is mentioned.

American Statistics Index 7
Bell & Howell Newspaper Indexes 4
CIS Index 5
Congressional Index 5
Congressional Quarterly Weekly Report 4
Congressional Record 5
Current Law Index 6
Digest of Public General Bills and Resolutions 5
EPA Publications Bibliography: Quarterly Abstract Bulletin 9
Environment Abstracts 9
Index to Legal Periodicals 6
Legal Resource Index 7
Library of Congress Subject Headings 2
Magazine Index 2
Major Legislation of the Congress 5
Monthly Catalog of United States Government Publications 6
National Journal 5
National Newspaper Index 4
New York Times Index 3
NEXIS 4
Official Washington Post Index 4
Pollution Abstracts 9
Public Affairs Information Service Bulletin 2
Reader's Guide to Periodical Literature 2
Selected Water Resources Abstracts 9
Social Science Index 3
Statistical Reference Index 7
Weekly Compilation Of Presidential Documents 6

References to data bases commercially available would include such sources as DIALOG, ORBIT, and BRS.

PART I. GENERAL REFERENCE SOURCES

BOOKS

Many libraries around the country, especially large college and research libraries, use Library of Congress subject headings in their catalogs. To learn how books on water policy are categorized in these libraries, consult the two volume guide, *Library of Congress Subject Headings*; it is usually kept near the automated or card catalog. The most relevant LC subject headings for water resource issues are listed below:

GENERAL:	Water resources development Water-supply Water conservation Water use Water consumption
ALLOCATION OF WATER:	Water--Law and legislation Water-supply Water-rights Watershed management Riparian rights Water, Underground Water districts Irrigation
WATER QUALITY:	Water quality Water quality management Water--Pollution Water, Underground--Pollution Federal aid to water quality management
POTABLE WATER:	Drinking water

JOURNAL ARTICLES

Citations to journal articles and other materials about water policy can be found in a number of printed indexes and online bibliographic data bases. The materials covered by the printed indeses are briefly described here and appropriate search terms are listed.

Online bibliographic data bases enable the researcher to locate citations to journal articles and other materials quickly by using a computer terminal to search a machine-readable file. Online data bases allow the researcher to combine search terms in ways that are impossible in a printed index or library catalog and to simultaneously search material that would be contained in printed index volumes covering several years. Many of the printed indexes described in this guide are also available as online data bases. Your reference librarian can advise you on the availability of computerized search services in your area; there may be a fee for use.

MAGAZINE INDEX (machine format)

Magazine Index provides citations to materials in over 400 popular magazines, focusing on coverage of current affairs, leisure time activities, arts, sports, and science and technology. References from the last five years are listed alphabetically by subject and author in one alphabetical display on the Magazine Index microfilm reader-terminal. The Index is updated monthly, and uses Library of Congress subject headings. Consult the list given above or the two-volume Library of Congress Subject Headings for appropriate search terms.

PUBLIC AFFAIRS INFORMATION SERVICE BULLETIN (PAIS)

PAIS is a subject index of books, pamphlets, government publications, reports of public and private agencies, and periodical articles relating to economic and social conditions, public administration, and international relations. It is issued twice a month; there are also three quarterly cumulations and an annual bound volume with an author index. Search terms are listed below.

GENERAL: Water
Water resources development
Water supply
Water conservation

ALLOCATION OF WATER: Water rights
Water, Underground
Water supply
Water supply, Rural
Riparian rights
Irrigation

WATER QUALITY: Water pollution
Water purification
Water, Underground

POTABLE WATER: Drinking water

READER'S GUIDE TO PERIODICAL LITERATURE

The Reader's Guide is an author/subject index to over 180 periodicals of general interest published in the U.S. and Canada. It is published twice a month September to December and March, April and June; it appears monthly in January, February, May, July, and August. The quarterly and annual cumulations can expedite your search.

GENERAL:	Water resources development
	Water conservation
	Water supply
ALLOCATION OF WATER:	Water rights
	Irrigation
WATER QUALITY:	Water pollution
	Water, Underground
	Water reuse
	Irrigation water
POTABLE WATER:	Drinking water
	Water purification

SOCIAL SCIENCE INDEX

Social Science Index gives author and title access to articles from political science, public administration, and other social science journals. A few environmental journals are indexed as well. The *Index* is published quarterly and as an annual bound volume.

GENERAL:	Water resources development
ALLOCATION OF WATER:	Water supply
	Water supply, Agricultural
	Water--Laws and legislation
	Water rights
	Water, Underground
	Irrigation
WATER QUALITY:	Water quality
	Water quality management
	Water pollution
	Water pollution control
POTABLE WATER:	Drinking water

NEWSPAPER ARTICLES

The following indexes may be used to locate newspaper articles on water policy issues.

NEW YORK TIMES INDEX

The *New York Times Index* provides extensive abstracts for articles appearing in the New York Times. It is issued twice a month, with quarterly and annual cumulations. Its use can be confusing; consult "How to use the New York Times Index" in an annual volume for guidance. Search under "Water" and "Water pollution."

BELL & HOWELL NEWSPAPER INDEXES

The Bell & Howell Co. produces a set of indexes which list articles appearing in the Boston Globe, Christian Science Monitor, Denver Post, Detroit News, Houston Post, Los Angeles Times, New Orleans Times-Picayune, San Francisco Chronicle, St. Louis Post-Dispatch and Washington Post.

OFFICIAL WASHINGTON POST INDEX

The Index provides access to all substantial newsworthy items in this paper. It is issued monthly and cumulated annually. Check under "Water," "Water supply," and "Water, Underground."

NEXIS

NEXIS is an online search and retrieval service with numerous subfiles of information. The NEXIS database includes the full text of many newspapers, including Legal Times, National Law Journal, the New York Times, the Washington Post, and the Christian Science Monitor; full text of major wire services, including AP, UPI, and Reuters; full text of many newsletters and magazines; full text of some government publications; abstracts to many current affairs magazines and major U.S. newspapers; and other information. Ask a reference librarian if NEXIS is available in your area.

NATIONAL NEWSPAPER INDEX (machine format)

National Newspaper Index, provides front-page to back-page indexing on current affairs topics in the Christian Science Monitor, New York Times, and Wall Street Journal, Los Angeles Times, and Washington Post. It is issued monthly on microfilm which library staff load into the microfilm reader-terminal. An online version is available through Dialog Information Retrieval Service.

LEGISLATIVE INFORMATION

Congressional activities on water policy issues may be monitored by searching the following printed publications.

CONGRESSIONAL QUARTERLY WEEKLY REPORT

Congressional Quarterly Weekly Report provides current information on congressional activities, the progress of major bills, and background information on major policy issues. Important recent articles are indexed on the back cover of each issue. Consult this index under the heading "Environment." A quarterly and an annual index are also issued; search these under the headings "Water projects" and "Water pollution".

Congressional Quarterly also published an annual volume which cumulates material from the weeklies. Search CQ Almanac under the headings "Water resources," "Water projects," "Water conservation," and "Water pollution."

NATIONAL JOURNAL

National Journal provides information on important executive branch and congressional actions. In addition to the annual index, there is a page titled "Recent Articles" toward the end of most issues. Look under "Environment" for references to the last nine weeks' articles on water policy.

Check the annual indexes under "Water" and "Pollution."

CONGRESSIONAL RECORD

The Congressional Record provides an edited transcript of the activities on the floor of the House and the Senate. It is published each day Congress is in session. Subject and name indexes are published biweekly and cumulated annually. Search under "Water," "Water pollution," and "Waterways."

BILLS AND RESOLUTIONS

MAJOR LEGISLATION OF THE CONGRESS (MLC)

The MLC provides summaries of selected major legislation arranged by subject. It includes background on the issues and information on the content and status of major bills affecting that issue. The publication may be examined at a Government depository library or purchased from the Government Printing Office. Search under the headings "Environmental protection" and "Natural resources."

DIGEST OF PUBLIC GENERAL BILLS AND RESOLUTIONS

The Digest summarizes the essential features of public bills and resolutions and changes made in them during the legislative process. The Digest is published during each session of Congress in two cumulative issues and a final issue at the conclusion of the session. The Digest has sponsor/cosponsor, identical bills, short title, and subject indexes. Search under "Water and water resources development" and "Environmental protection and conservation."

CIS INDEX (Index to the Publications of the United States Congress)

The CIS Index, produced by the Congressional Information Service, abstracts all congressional publications with the exception of the Congressional Record. The Index is published monthly and cumulated quarterly and annually. Each issue of the Index is divided into index and abstract portions. Search under "Water resources development," "Water supply," and "Water pollution" in the index portion to identify relevant abstracts.

CONGRESSIONAL INDEX

The Congressional Index, published by the Commerce Clearing House, is a weekly looseleaf service provides content and status information for bills and resolutions pending in Congress. The progress of bills and resolutions is reported from the introduction of the legislation to the final disposition. Terms to be searched in this index are "Public works," "Environmental protection," and "Utilities".

GOVERNMENT PUBLICATIONS

MONTHLY CATALOG OF UNITED STATES GOVERNMENT PUBLICATIONS

The Monthly Catalog lists documents issued by all branches of the Federal Government. The Catalog has monthly, semiannual, and annual indexes arranged by author, title, subject, keywords, and series/report title.

WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS

The Weekly Compilation of Presidential Documents contains statements, messages, and other presidential materials released by the White House during the preceding week. The Weekly Compilation has weekly, quarterly, and annual indexes.

Statements of other Executive branch officials may be found in such sources as Executive agency publications, Congressional hearings, and in weekly news programs.

LEGAL MATERIALS

Law review articles may prove especially useful in arguing the first debate resolution.

CURRENT LAW INDEX

Current Law Index covers over 700 law periodicals. It is published in eight monthly issues, three quarterly cumulations, and an annual cumulation.

GENERAL:	Water
	Water resources development
	Water conservation
ALLOCATION OF WATER:	Water-rights
	Water-supply
	Water transfer
	Water, Underground
WATER QUALITY:	Water-pollution
	Water quality
	Water, Underground
POTABLE WATER:	Drinking water

INDEX TO LEGAL PERIODICALS

The Index to Legal Periodicals is a subject and author index to legal articles, yearbooks, institutes, and reviews of works published in the the U.S., Canada, and other English-speaking countries. The Index is published monthly except September, with a bound cumulation each year. Check under "Water and watercourses" and "Pollution--water."

LEGAL RESOURCE INDEX (Machine format)

Like Magazine Index and National Newspaper Index, Legal Resources Index is a microfilm reader-terminal which displays references on a screen. Legal Resource Index includes over 700 law journals, seven legal newspapers and relevant law materials from Magazine Index, and National Newspaper Index. The Index is arranged in four separate sections: subject, author/title, table of cases, and table of statutes. When the Index is supplemented, a new cumulative microfilm is provided.

STATISTICAL SOURCES

AMERICAN STATISTICS INDEX (ASI)

The American Statistics Index, indexes and describes the statistical publications of the U.S. Government, including periodicals, annuals, biennial, semiannual, and special publications. The Index provides access to statistical materials by subject, organization, name, issuing source, and title. The Index is published monthly and cumulated quarterly and annually. ASI is available online commericially.

STATISTICAL REFERENCE INDEX (SRI)

The Statistical Reference Index provides a guide and index to selected statistical reference material from non-Federal sources on a wide spectrum of subject matter. It includes the publications of trade, professional, and other non-profit associations and institutions, business organizations, commercial publishers, university and independent research centers, and State government agencies. The Index provides access by subject, organization, name, issuing source, and title. The Index is published monthly and cumulated annually.

PART II: WATER POLICY REFERENCE SOURCES

REFERENCE BOOKS

Giefer, Gerald J. Sources of information in water resources: an annotated guide to printed materals. Port Washington, N.Y., Water Information Center, 1976. 290 p.
"Cites and annotates over 1100 titles found useful for reference purposes in the water resources field."

Giefer, Gerald J., and David K. Todd. Water publications of State agencies: a bibliography of publications on water resources and their management published by the States of the Untied States: first supplement, 1971-1974. Edited by Gerald J. Giefer and David K. Todd, with the assistance of Beverly Fish. Huntington, N.Y., Water Information Center, 1976. 189 p.
Lists water resources publications issued by State agencies and provides information on obtaining them. This volume updates a 1972 volume of the same title.

Handbook of water quality management planning. Edited by Joseph L. Pavoni. New York, Van Nostrand Reinhold, 1977. 419 p.

(Van Nostrand Reinhold environmental engineering series)

Contents.--Development of water quality management planning in the United States, by G. Noble and E. Finley.--Relationships between water quality management and land use planning, by R. Alderfer and E. Lovelace. --Evaluation of wastewater treatment alternatives, by J. Pavoni and J. Perrich.--Utilization of modeling in water quality management studies, by E. Fosee and J. Tapp.-Management-institutional aspects of water quality management planning, by E. Lovelace and T. Cantine.--Public participation in water quality management planning, by C. Schimpeler, M. Gay, and A. Roark.--Environmental assessments in water quality management planning, by J. Heer, Jr., and D. Hagerty.

Handbook of water resources and pollution control. Edited by Harry W. Gehm, and Jacob I. Bregman. New York, Van Nostrand Reinhold, 1976. 840 p.

Partial contents.--Water quantity requirements for public supplies and other uses, by J. Kammerer.--Water storage and distribution, by R. McWhinnie and P. Johnson.--Developing groundwater resources, by C. Briggs.--Preparing potable water, by J. Vaughn .--Water in industry, by R. Parlante.--Cost allocation and recovery for combined municipal and industrial waste treatment facilities, by E. Brill, Jr., and J. Geyer.

Knight, Allen W., and Mary Ann Simmons. Water pollution: a guide to information sources. Detroit, Mich., Gale Research Co., 1980. 278 p.

Lists and describes publications, databases, films, and organizations in the field of water pollution. Includes glossary and list of selected readings.

Krenkel, Peter A., and Vladimir Novotny. Water quality management. New York, Academic Press, 1980. 671 p.

This treatise covers "the fundamentals of water quality; legal aspects; physical, chemical, and biological dimensions of water quality; water quality requirements; pollution inputs from both point and nonpoint sources; stream and reservoir water quality modeling; eutrophication; thermal pollution; and groundwater quality."

McGraw-Hill encyclopedia of science & technology: an international reference work in fifteen volumes including an index. 5th ed. New York, McGraw-Hill, 1982.

Nemerow, Nelson Leonard. Industrial water pollution: origins, characteristics, and treatment. Reading, Mass., Addison-Wesley Pub. Co., 1978. 738 p.

This textbook provides detailed information on individual industries' effects on water supplies. Includes many references.

Todd, David Keith. The water encyclopedia; a compedium of useful information on water resources. Port Washington, N.Y., Water Information Center, 1970. 559 p.

Presents data in tabular form.

Includes sections on climate and precipitation, hydrologic elements, surface and ground water, water use, water quality and pollution control, water resources management, agencies and organizations, and constants and conversion factors.

Vesilind, P. Aarne, and J. Jeffrey Pierce. Environmental pollution and control. 2nd ed. Ann Arbor, Mich., Ann Arbor Science Publishers, 1983. 395 p.
This textbook presents nontechnical explanations and discussions of environmental science and policy topics. Includes chapters on water pollution, measurement of water quality, water supply, water treatment, sludge treatment and disposal, nonpoint source water pollution, water pollution law, and the environmental ethic.

INDEXES

Environment Abstracts, a monthly abstract journal, and its annual counterpart, Environment Index, identify information covering scientific, political and socio-economic aspects of environment and resource issues. It lists articles, books, conference papers, government reports etc., by subjects and geographic area.

EPA Publications Bibliography: Quarterly Abstract Bulletin lists reports of the Environment Protection Agency by title, keyword, sponsoring EPA office, corporate author, personal author, and contract/grant number. Includes a list of libraries holding complete sets of EPA reports on microfiche is given at the back, as well as order information for purchasing reports from the National Technical Information Service.

Pollution Abstracts, published six times a year, organizes, summarizes, and indexes world-wide technical litesrature on environmental pollution. Scientific journals and technical reports are the major sources of information scanned.

Selected Water Resources Abstracts, a monthly publication, is produced by Geological Survey, U.S. Dept. of the Interior. It covers biological, physical, and social science aspects of water, listing journal articles, reports, and other types of literature. Author, subject, organization, and accession number indexes are provided each month and in an annual cumulation.

LEGISLATIVE AND LEGAL INFORMATION

The Environmental and Energy Study Conference Weekly Bulletin is an especially good source for monitoring the status of environmental legislation being considered by Congress.

The Environmental Law Reporter is a looseleaf service produced by the Bureau of National (BNA), which provides timely and comprehensive coverage of environmental law developments, including Federal and State court opinions, actions in pending cases, legislative developments, Federal agency rulemaking, and Supreme Court Actions. The Report also contains analytic comments, and an annual listing of writings on environmental law and policy published during the past year in law school reviews and other legal journals. There is also a statutes binder, which contains the full text of roughly one hundred Federal statutes and international agreements concerning environmental matters.

The Environment Reporter is a BNA looseleaf service which presents the text of Federal and State environmental laws and regulations and discusses important decisions. The Reporter also includes a weekly current developments section which reviews proposed regulations, legal actions, and new studies.

The *International Environmental Reporter* presents the texts of treaties, bilateral agreements, and conventions concerning environmental issues. This BNA looseleaf service reprints the texts of foreign environmental laws. Like the other Bureau of National Affairs reporters cited above, it includes a current developments report.

SELECTED PERIODICALS

Periodicals focusing on water include:

American Water Works Association Journal (monthly)
Clean Water Action News (6 times per year)
Groundwater Monitoring Review (quarterly)
Journal of the Water Pollution Control Federation (monthly)
Land and Water Law Review (semi-annually)
National Water Conditions (monthly)
Water/Engineering Management: Journal of Water Quality Management (monthly)
Water Newsletter; Water Supply, Waste Disposal,
  Conservation, Pollution (semi-monthly)
Water Research: the Journal of the Association
Water Pollution Research (monthly)
Water Resource Bulletin (bi-monthly)
Water Resources Research (bi-monthly)
Water Well Journal (monthly)

Newsletters tracking water issues include:

The Groundwater Newsletter (bi-monthly)
Interstate Conference on Water Problems (ICWP) (monthly)
Washington Report (monthly)
Water Information News Service (semi-monthly)

The following periodicals frequently contain articles on environmental and natural resource policy issues:

Chemical & Engineering News (weekly)
Chemical Week (weekly)
Environment (10 times a year)
Environmental Action (10 times a year)
Environmental Forum (monthly)
Environmental Science & Technology (monthly)
EPA Journal (monthly)

Weekly newsletters of environmental interest:

Air/Water Pollution Report
Environment Report
Environment Reporter
Environmental and Energy Study Conference Weekly Bulletin
Inside E.P.A.
Inside EPA's Environmental Policy Alert

SELECTED ORGANIZATIONS

The following selected organizations focus on water issues and may be sources of information on water policy. Most were selected from the Encyclopedia of Associations, as were the brief descriptions of the groups.

American Water Resources Association
5410 Grosvenor Lane, Suite 220
Bethesda, MD 20819
(301) 493-8600

Members include engineers, scientists, businesses, and organizations. Seeks to advance water resources research, planning, development, and management.

American Water Works Association
6666 W. Quincy Ave.
Denver, CO 80235
(303) 794-7711

Serves the water utilities industry and personnel interested in public water supply. Maintains a technical library and information center on water utilities industry, potable water, and water reuse. Produces WATERNET database.

Clean Water Action Project
733 15th St., N.W., Suite 1110
Washington, D.C. 20005

This national citizen action organization was established to work for strong pollution controls and safe drinking water. It is active in preservation of wetlands and promotion of sewerage recycling and alternative waste water treatment technologies.

Interstate Conference on Water Problems
21 Dupont Circle, N.W., Suite 600
Washington, D.C. 20036
(202) 466-7287

Members are State, interstate, and intrastate official with responsibility for all water quantity and quality related matters. Facilitates interstate cooperation and exchange of information. Presents views to Congress and Federal agencies. Maintains speakers bureau. Researches water management, water for energy, and water technology.

National Demonstration Water Project
1725 DeSales St., N.W., Suite 402
Washington, D.C. 20036
(202) 659-0661

This alliance of private, locally based organizations engaged in facilitating, through development and establishment of water and wastewater systems, the delivery of adequate and affordable drinking water and waste water disposal services to low income rural areas. Conducts research.

National Water Alliance
50 E St., S.E.
Washington, D.C. 20003
(202) 546-0917

This bipartisan organization works toward the formation of water policy at the Federal level.

National Water Resources Association (NWRA)
955 L'Enfant Plaza, S.W., Suite 1202 N.
Washington, D.C. 20024
(202) 488-0610

Members are officers of irrigation districts, canal companies, businesses and others interested in the development, control, conservation and utilization of water resources in the reclamation States (18 Western States).

National Water Well Association
500 W. Wilson Bridge Rd.
Worthington, OH 43085
(614) 846-9355

Encourages scientific education, research and development of standards in the development and use of underground water supplies. Operates National Ground Water Information Center Data and Waterline.

Soil Conservation Society of America
7515 N.E. Ankeny Rd.
Ankeny, IA 50021
(515) 289-2331

Members are soil and water conservationists. Seeks to improve members' technical or administrative competence in a conservation-related field.

Water Pollution Control Federation
2626 Pennsylvania Ave., N.W.
Washington, D.C. 20037
(202) 337-2500

Members include engineers, water pollution control works superintendents, chemists, operators, educational and research personnel, municipal officals, and equipment manufacturers interested in water pollution control. Works to advance fundamental and practical knowledge concerning wastewater treatment.

Water Resources Congress
3800 N. Fairfax Dr., Suite 7
Arlington, VA 22203
(202) 488-0688

Members are State, city and county agencies; water and land development associations; agricultural, commercial, industrial, labor and civic organizations; business firms and individuals in navigation, irrigation, flood control, water supply and water quality. Works to promote the continued improvement, development, and utilization of the Nation's rivers, harbors, lakes, and water and land resources.

These environmental groups may also be helpful:

Environmental Action
1346 Connecticut Ave., N.W., Suite 731
Washington, D.C. 20036
(202) 833-1845

National political lobby organization with close ties to 5000 local, State and campus ecology groups.

Environmental Defense Fund
444 Park Ave., S.
New York, N.Y. 10016
(212) 686-4191

National environmental organization operating as a team of lawyers and scientists combining their skills to end "environmental degradation."

Environmental Law Institute
1346 Connecticut Ave., Suite 600
Washington, D.C. 20036
(202) 452-9600

Purposes are: to conduct and sponsor research on environmental law and policy; to maintain a clearinghouse for information regarding environmental law; and to engage in related educational activities.

Environmental Policy Institute
218 D St., S.W.
Washington, D.C. 20003
(202) 544-2600

Public interest research and education environmental organization. Analyzes and provides information on Federal environmental and energy programs and policies, makes available reports to citizens' organizations, government agencies, and industry interest groups.

National Environmental Development Association
3 National Press Building
Washington, D.C. 20045
(202) 638 -1230

Believes that: both public and private interests benefit from a reasoned credible approach to the challenges of the environmental-economic inter-relationship; and private enterprise must not be the victim of the war on pollution.

National Wildlife Federation
1412 16th St., N.W.
Washington, D.C. 20036
(202) 797-6800

Areas of interest: conservation of wildlife and natural resources; wildlife management; environmental policy; natural history; outdoor recreation; conservation education.

Natural Resources Defense Council
122 E. 42nd Street
New York, N.Y. 10017
(212) 949-0049

Works to increase public understanding of the means by which the law may be used to protect resources.

Resources for the Future
1755 Massachusetts Ave., N.W.
Washington, D.C. 20036
(202) 328-5000

Conducts research and education in public policy issues related to conservation, use and development of natural resources, energy and environmental quality.

Sierra Club
530 Bush St.
San Francisco, CA 94108
(415) 981-8634

Lobbies for environmental legislation at all government levels.

Many governmental bodies have responsibility for water resources. Consult the United States Government Manual for identification and description of them. Among the key agencies are:

Army Corp of Engineers
Office of the Chief of Engineers
U.S. Department of the Army
Washington, D.C. 20314
(202) 272-0010

Among the Corps' programs are research and development, planning, design, construction, operation and maintenance, and real estate activities related to rivers, harbors, and waterways.

Bureau of Reclamation
Office of Public Affairs
U.S. Department of the Interior
Washington, D.C. 20240
(202) 343-4662

This agency assists States, local governments, and other Federal agencies to stabilize and stimulate local and regional economies, enhance and protect the environment, and improve the quality of life through development of water, other renewable resources, and related land resources throughout the 17 contiguous Western States.

Department of the Interior
Interior Building
C Street between 18th and 19th Streets, N.W.
Washington, D.C. 20240
(202) 343-3171

This Department has responsibility for most of the nationally owned public lands and natural resources.

Environmental Protection Agency
401 M St., S.W.
Washington, D.C. 20460
Water Programs (202) 382-5700

EPA's water quality activities include development of national programs, technical policies, and regulations for water pollution control and water supply and enforcement of standards.

Geological Survey
Public Affairs Officer
U.S. Department of the Interior
119 National Center
Reston, VA 22092
(703) 860-7444

Among the Survey's responsibilities are gaging streams, determining the water supply of the U.S., and classifying federally owned lands for water power potential.

International Boundary and Water Commission, United States and Mexico
Executive Center
4110 Rio Bravo
El Paso, Texas 79902
(915) 541-7300

Implements treaties and works on water distribution, regulation, quality, and use at U.S.-Mexican border areas.

Soil Conservation Service
Public Information Staff
U.S. Department of Agriculture
P.O. Box 2890
Washington, D.C. 20013
(202) 447-4543

The agency is responsible for developing and carrying out a national soil and water conservation program in cooperation with landowners and operators and other land users and developers, with community planning agencies and regional resource groups, and with other Federal, State, and local government agencies. SCS also assists in agricultural pollution control, environmental improvement, and rural community development.

UNITED STATES GOVERNMENT PRINTING OFFICE
SUPERINTENDENT OF DOCUMENTS
WASHINGTON, D.C. 20402

SB-043
April 8, 1985

PUBLICATIONS RELATING TO THE 1985-86 HIGH SCHOOL DEBATE TOPIC

United States Water Policy: What is the most effective water policy for the United States?

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___America's Soil and Water: Condition and Trends. *Concerns the soil and water resources in the rural nonfederal land of the United States where our crops are grown, where much of our livestock is pastured and grazed, and where our private forests are managed. Discusses the approaches and programs that attempt to deal with soil and water resource problems.* 1982: 34 p.; ill. revised ed.
S/N 001-000-04313-7 $ 3.75

Code of Federal Regulations, Title 18, Conservation of Power and Water Resources, Revised April 1, 1984:

___ Part 1-149. 1984: 597 p.
GS 4.108:18/pt.1-149/984 S/N 022-003-95323-0 12.00

___ Microfiche of the above. 1984: 7 microfiche, 24X.
GS 4.108:18/pt.1-149/984 MF
S/N 022-003-98613-8 2.25

___ Part 150-399. 1984: 978 p.
GS 4.108:18/pt.150-399/984 S/N 022-003-95324-8 15.00

___ Microfiche of the above. 1984: 11 microfiche, 24X.
GS 4.108:18/pt.150-399/984 MF
S/N 022-003-98614-6 2.25

___ Part 400-End. 1984: 292 p.
GS 4.108:18/pt.400-end/984 S/N 022-003-95325-6 6.50

___ Microfiche of the above. 1984: 4 microfiche, 24X.
GS 4.108:18/pt.400-end/984 MF
S/N 022-003-98615-4 2.25

___Costs of Direct Filtration to Meet Drinking Water Regulations. 1979: 33 p.; ill.
EP 1.2:W 29/49 S/N 055-000-01083-4 4.50

___Evaluation of Trends in the Acidity of Precipitation and the Related Acidification of Surface Water in North America. 1983: 21 p.; ill.
I 19.13:2249 S/N 024-001-03500-6 2.75

Global 2000 Report to the President: Entering the Twenty-First Century:

___ Volume 1, Summary Report. *Summarizes the Global 2000 Study of the probable changes in the world's population, natural resources, and environment through the end of the century.* 1980: 47 p.; ill.
PrEx 14.2:G 51/2000/v.1 S/N 041-011-00037-8 $ 5.00

___ Volume 2, Technical Report. *This is a technical report of the Global 2000 Study on projections of population, GNP, climate, agriculture, water, environment, energy, minerals, and technology; with interconnections and feed back. This study will be used as a foundation for long-term policy planning.* 1980: 766 p.; ill., 16 plates.
PrEx 14.2:G 51/2000/v.2 S/N 041-011-00038-6 14.00

___ Volume 3, Documentation on the Government's Global Sectoral Models; the Government's "Global Model." 1981: 411 p.; ill.
PrEx 14.2:G 51/2000/v.3 S/N 041-011-00051-3 9.50

___Ground-Water Regions of the United States. *Describes how the ground water systems in the 15 ground water regions of the United States, Puerto Rico and Virgin Islands are divided. Includes maps that show the boundaries of the regions and tables that summarize the physical and hydrologic characteristics of the regions.* 1984: 88 p.; ill.
I 19.13:2242 S/N 024-001-03516-2 4.25

___Manual of Individual Water Supply Systems. *Manual contains information useful in development of individual water systems. It is intended for use by Federal agencies, State and local health departments, well drillers, contractors, individual homeowners, and owners and operators of private and public institutions.* 1982: 163 p.; ill.
S/N 055-000-00229-1 6.00

___National Water Summary, 1983: Hydrologic Events and Issues. *Topics covered include: Man and the hydrologic cycle; select hydrologic events from January 1982 through August 1983; hydrologic perspectives on water issues; and State water issues.* 1983: 249 p.; ill.
I 19.13:2250 S/N 024-001-03505-7 9.00

___Potential Climate Impacts of Increasing Atmospheric CO2 With Emphasis on Water Availability and Hydrology in the United States. 1984: 116 p.; ill.
EP 1.2:C 61/2 S/N 055-000-00241-0 4.50

___Selected Papers in the Hydrologic Sciences 1984. *This publication emphasizes new methods, ideas, techniques or innovative applications of known techniques to solve hydrologic problems.* 1984: 72 p.; ill.
I 19.13:2262 S/N 024-001-03523-5 3.00

___Soil and Water Conservation News. (Monthly.) *Official organ of the Soil Conservation Service. Contains interesting and informative articles on new developments and happenings in the field of soil and water conservation.* Subscription price: Domestic - $18.00 a year; Foreign - $22.50 a year. Single copy price: Domestic - $1.75 a copy; Foreign - $2.19 a copy. [SC] (File Code 2M) A 57.9/2: S/N 701-044-00000-2

___Water in America 1983: A Report by the Office of Water Policy to Accompany the United States Geological Survey's National Water Summary. *Includes the following topics: major policy issues, improving river management, resolving interstate water conflicts, water project development, Indian water claims, and acid rain and salinity effects on water quality.* 1983: 18 p.; ill.
I 29.2:W 29/39 S/N 024-000-00883-5 $ 1.75

___Water-Related Technologies for Sustainable Agriculture in United States Arid/Semiarid Lands. *Covers the following topics: improving efficiency of water use for rain-fed systems or irrigation, improving water management, storage, and distribution for agriculture and augmenting existing supplies.* 1983: 419 p.; ill.
Y 3.T 22/2:2 W 29/2 S/N 052-003-00930-7 8.50

___Water Resources Research Act of 1984, Public Law 98-242. An Act to Authorize an Ongoing Program of Water Resources Research, and for Other Purposes. Approved March 22, 1984. 1984: 12 p.
GS 4.110:98/242 S/N 022-003-95997-1 1.75

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Where to Order	Superintendent of Documents U.S. Government Printing Office Washington, D.C. 20402
How to Remit	Regulations require payment in advance of shipment. Checks or money orders should be made payable to the Superintendent of Documents. Orders may also be charged to your Superintendent of Documents prepaid deposit account with this Office, MasterCard or VISA. If credit card is used, please by sure to include its date of expiration. Postage stamps are not acceptable.
Please Note	Supplies of Government documents are limited and prices are subject to change without prior notice.

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